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THE USE OF LAMINAGRAPHY WITH ENCEPHALOGRAPHY IN THE DIAGNOSIS OF MIDLINE AND SUBTENTORIAL BRAIN TUMORS*

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INTRODUCTION

PNEUMO-ENCEPHALOGRAPHIC visualization of the third and fourth ventricles, the aqueduct of Sylvius, the basilar cisterns and the cerebellum is an important, and frequently the most difficult part of the investigation. This is particularly true when ventriculography is performed, and it is often in those patients with suspected midbrain or posterior fossa disease who require ventriculography that information concerning the midline structures is most necessary. If an adequate quantity of air enters the ventricular system the third ventricle may be outlined fairly well in a good proportion of patients. The percentage of visualizations of the third ventricle may be increased by the maneuvers recommended by Twining.[15] The fourth ventricle and the aqueduct of Sylvius are more difficult to outline, particularly during ventriculography. The various manipulations of the head such as those advised by Lysholm[10] are usually unsuccessful.[12] Opaque encephalography using lipiodol[11] or thorotrast[15] advised for a short time has been discarded because of the risk to the patient. The paranasal sinuses, the mastoid cells and petrous pyramids, and air in the convolutional sulci and the basilar cisterns may further obscure the air-containing midline structures.

Many of these difficulties may be overcome by means of body section roentgenography, a technique whereby roentgenograms of preselected planes within a structure can be made.[7] Its application to the roentgenologic investigation of the chest and skull is well known.[6,13] In 1937 Carillo, Oribe and Malenchini[2] advised laminagraphy as an adjunct to pneumoencephalography for visualization of the third and fourth ventricles, the cerebellum and the basilar cisterns. Turner and Lutz[9,14] independently described the advantages of laminagraphy with pneumo-encephalography, and stated that it might visualize the fourth ventricle when routine roentgenograms failed to do so.

Our previous experiences with laminagraphy of the skull[4,5] instantly confirmed the possibilities pointed out by these authors, and laminagraphy was added to

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our routine roentgenographic procedures with pneumo-encephalography. During the past two years over one hundred such laminagraphic examinations were performed. These have convinced us that its addition to the routine pneumo-encephalographic technique is most desirable, particularly when information concerning the midline structures is sought.

TECHNIQUE

We use the Kelley-Koett Kieffer laminagraph[8] and regard it as an efficient apparatus capable of producing body section roentgenograms of consistently good quality accurately and repeatedly, with no delay or inconvenience to the patient. Pneumo-encephalography is first performed and stereoroentgenograms are made in the erect and supine positions in the lateral, posteroanterior and anteroposterior projections. It is sometimes possible to introduce gas into the anterior half of the third ventricle by placing the patient in the supine position with the head in hyperextension, tilting the table so that the orbitomeatal line is horizontal, and making the roentgenographic exposure in the lateral projection.

After the standard exposures are completed and the wet films examined, the patient is transferred to the laminagraphic room and placed in the recumbent prone position. The head is positioned as for a lateral roentgenogram and the midline of the skull is measured from the table top. A lateral laminagram is made through the sagittal plane in the midline and either 0.5 or 1 centimeter above the midline as desired, with the head in the right and left lateral positions. This permits the gas to ascend to the portion of the ventricular system which is uppermost, so that the left lateral position permits gas to ascend towards the right side and vice versa. Not infrequently a true midline laminagram will not reveal the aqueduct of Sylvius and other midline structures because of intracranial disease, while other sections slightly off center might prove more informative. A routine series consists of a center cut laminagram and cuts 1 cm. to the right and left of the midline. Other studies are made as required by the individual patient.

Our results with laminagraphy in the posteroanterior and anteroposterior positions have not warranted the inclusion of these projections in our routine work. However, if there is any possibility of deriving further information we do not hesitate to use these projections.

The technique which has proved most satisfactory is a five spiral motion, five seconds' exposure, 150 milliampere-seconds and 60 to 65 kilovolts for the average patient. It is desirable to focus the roentgen-ray beam so that the field of exposure coincides with the film size, the 10 by 12 centimeter film being used most often. If finer detail is desired the field may be further limited centering the beam on the area to be examined.

If the Kieffer apparatus is not available, readable but less satisfactory laminagrams may be obtained with apparatus using rectilinear motion only. Several devices have been described which enable one to adapt the usual roentgenographic table and tube stand for body section roentgenography.[1]

NOTES ON THE NORMAL ROENTGENOGRAPHIC ANATOMY OF THE MIDLINE STRUCTURES

The normal third ventricle is a midline cavity which is more or less trapezoidal in shape in the sagittal plane and lenticular in the coronal plane. It is connected with the lateral ventricles by the foramen of Monro rostrally and the fourth ventricle by the aqueduct of Sylvius caudally. Its anterior wall from above downwards is formed by the anterior pillars of the fornix, the anterior commissure and the lamina terminalis. If front lies the small cisterna cinereae laminae terminalis, and beneath this is the cisterna chiasmaticus. The optic recess forms the inferior angle, extending downwards from above and somewhat dorsal to the optic chiasm.

The floor of the third ventricle is formed

by the optic chiasm and the infundibulum. The optic chiasm cistern extends around from the front of the third ventricle to lie inferior to the optic chiasm and anterior to the infundibulum. The posterior aspect of the floor proceeding dorsally is formed by the tuber cinereum, the mammillary bodies, the posterior perforated space, the cerebral peduncles and the tegmentum of the midbrain. Beneath the floor of the third ventricle extending from behind the infundibulum to the cerebral peduncles lie the large cisternae interpeduncularis. The ventricular wall thickens as it passes caudad over the mammillary bodies, and rises rather sharply towards its posterior half. The anterior half is thin, a factor which explains the tendency for the ventricle to dilate principally in that region.

The posterior wall from below upwards slopes backwards and consists of the rostral end of the aqueduct of Sylvius, the posterior commissure, the pineal recess and the pineal body and the suprapineal recess. The cisternae ambiens encircling the brain stem lies above and to either side of the posterior wall in close relationship with the cerebral peduncles. This may measure 5 to 7 mm. in depth over the collicular plate.

The roof of the third ventricle curves backwards with a slight arch, following the arch of the fornix. It is covered by the velum interpositum, a thin layer of epithelium stretched between the thalami from which are suspended the parasagittal strips of choroid plexus running the length of the third ventricle. The vertical measurement of the third ventricle is variable, averaging more than 2 cm. Its width varies from 2 to 8 mm. The most constant measurement is from the foramen of Monro to the rostal end of the aqueduct of Sylvius in the lateral projection, averaging 2.6 cm.

The lateral walls of the third ventricle are formed by the medial surfaces of the thalami and the hypothalamus. The chamber is usually crossed at its midportion by a mass of gray matter known as the massa intermedia.

The aqueduct of Sylvius is a narrow midline canal connecting the third and fourth ventricles, about 1.5 cm. long and varying from 1 to 2 mm in width. Its rostral half courses almost horizontally, curving

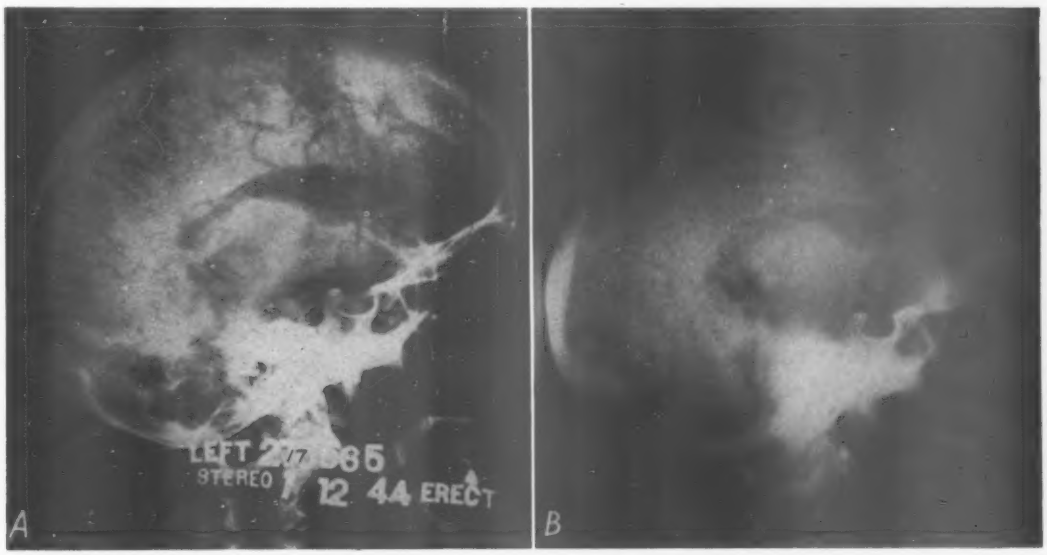

Fig. 1. *A*, left lateral pneumo-encephalogram. The fourth ventricle is obscured by the overlying mastoid cells. *B*, the lateral midline laminagram sharply reveals the gas-filled fourth ventricle which is normal in size, shape and position.

sharply ventrally at its midportion to assume an almost vertical position. Its roof is formed by the posterior commissure and the quadrigeminal plate, above which lies the cisterna ambiens. Its floor is formed by the tegmentum of the midbrain and the the subependymal gray matter peripheral to which the cerebral peduncles lie.

The fourth ventricle is rhomboid in shape in the coronal plane and roughly shaped like an isosceles triangle in the lateral projection. It is connected dorsally with the aqueduct of Sylvius, ventrally with the central canal of the medulla oblongata and caudally and laterally with the cisterna magna by the foramina of Magendie and Luschka respectively. The floor of the fourth ventricle is formed by the pons and the cephalic half of the medulla. Its roof is formed by the superior medullary velum rostrally and the cerebellum caudally. The choroid plexus of the fourth ventricle is attached to the ventral surface of the posterior medullary velum, and the roof is completed caudally by the tenia of the fourth ventricle and the obex.

The lateral boundaries on each side of the fourth ventricle are the superior, middle and inferior peduncles of the cerebellum from before backwards, covered on the ventricular side by the ependymal and subependymal gray matter, the eminentia cuneatus and the eminentia gracilis.

In the posteroanterior view the lateral recesses of the fourth ventricle may be outlined to either side of the floor, while in the lateral projection these may appear as heavier air shadows close to the floor of the ventricle in its midportion. In the lateral projection the posterior inferior wall of the fourth ventricle frequently presents an inward protuberance formed by the choroid plexus and the nodulus of the cerebellum. Normally the distance between the dorsum sellae and the floor of the fourth ventricle varies from 3.3 to 4.0 cm.

The cisterna pontis lies ventral to the pons and usually measures from 5 to 12 mm. in depth in the lateral projection. The body of the pons may be outlined between the cisterna pontis and the floor of the fourth ventricle. Its thickness averages about 2.8 cm.

The cisterna magna is continuous with the subarachnoid space of the spinal canal. It extends over the dorsal aspect of the medullar oblongata and the tela choroideae inferior of the fourth ventricle, and continues between these structures and the caudal and ventral portion of the vermis of the cerebellum, and extends laterally over the cerebellar hemispheres. Its depth in the midline averages about 2 cm. Cephalically and ventrally it is continuous with the cisterna pontis.

Occasionally sufficient air gathers in the convolutional sulci of the cerebellum so that its dorsal aspect may be well outlined. The anterior lobe may be seen dorsal to and rising slightly above the level of the corpora quadrigemina, and the larger posterior lobe forming the superoposterior and inferior aspect of the cerebellum completes the rather triangular configuration seen on the pneumo-encephalogram.

NOTES ON THE PATHOLOGICAL ROENTGENOGRAPHIC ANATOMY OF THE MIDLINE STRUCTURES

The roentgenologic localization of tumors of the midbrain, pons, cerebellum and adjacent structures rests on the effect of these on the midline structures as visualized by means of gas. The differential diagnosis between posterior fossa or midbrain tumors and inflammatory lesions occluding the aqueduct of Sylvius or the foramina of Magendie and Luschka may be very difficult, and often depends on adequate visualization of these structures. The basic criteria are filling or nonfilling of the ventricles, ventricular displacement or dilatation and the demonstration of intraventricular shadows.

Intraventricular tumors may arise from the ependymal linings (ependymomas), from the neuroglia close to the ventricles (gliomas) or from the choroid plexus (papillomas). Colloid cysts, which seem to occur only in the third ventricle, may spring from

the paraphysis. Meningiomas may arise from the tela choroideae. These may manifest themselves roentgenologically as both intraventricular defects and displacement of the ventricles. Absence of filling of the third ventricle with adequate visualization of the lateral ventricles is considered strongly suggestive of intrinsic disease, but nonfilling of the fourth ventricle is much more difficult to evaluate. Lateral displacement of the third and fourth ventricles by supratentorial masses such as low parietal or temporal lobe tumors must not be confused with infratentorial or midline masses.

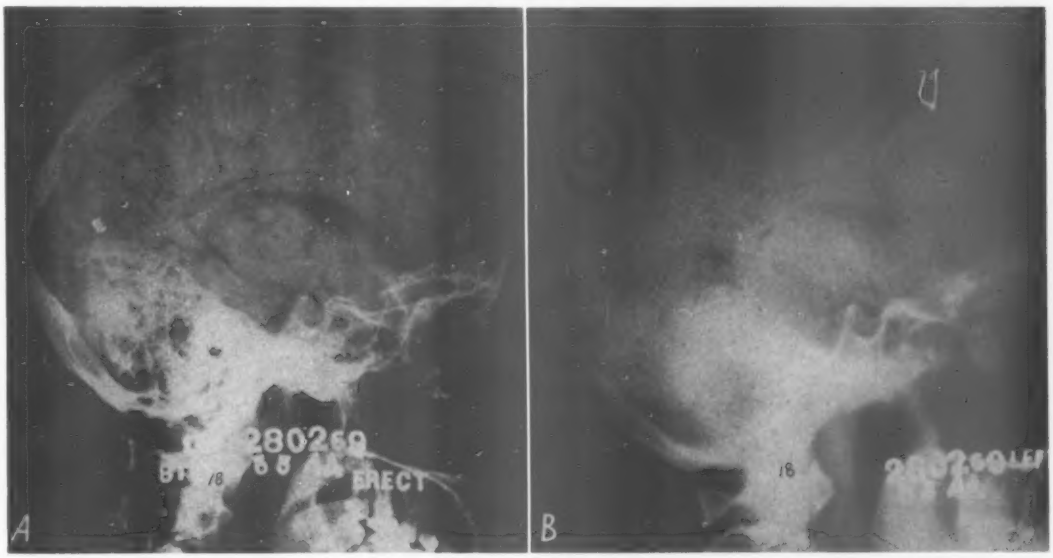

Fig. 2. *A*, left lateral pneumo-encephalogram. The cerebral sulci are well outlined, but the cerebellar sulci are obscured, as is the fourth ventricle. *B*, the lateral midline laminagram outlines the posterosuperior cerebellar sulci. The fourth ventricle and aqueduct of Sylvius likewise are visualized.

Tumors arising from neighboring structures may invaginate into the adjacent air-filled structures. Among these are Rathke's pouch tumors, chiasmal tumors, pinealomas, aneurysms of the circle of Willis or its main branches, gliomas of the basal ganglia and the quadrigeminal plate, suprasellar or olfactory groove meningiomas. Adamantinomas completely blocking the third ventricle have been described.

Stenosis of the aqueduct of Sylvius either on a congenital, inflammatory or obstructive basis must also be considered when this structure is not visualized during pneumo-encephalography and when the lateral and third ventricles are dilated. Hydrocephalic dilatation of the anterior aspect of the third ventricle resulting in enlargement of the sella turcica must be borne in mind when the differential diagnosis of intrasellar tumors is considered. Inasmuch as the anterior wall of the third ventricle is thinnest, dilatation of that structure may cause it to balloon downwards and forwards exerting pressure on the sella resulting in enlargement and atrophy.

Cerebellar tumors arising from the midline, such as hemangioblastomas, may displace the aqueduct of Sylvius anteriorly.[3] Tumors arising from its inferior aspect may produce dilatation of the aqueduct as well as the anterior portion of the fourth ventricle, while tumors springing from its superior surface may result in dilatation of the aqueduct and compression of the fourth ventricle. A shift of the fourth ventricle to either side may aid in lateral localization. Intraventricular tumors may be visualized as such if the cavity is not obliterated.

Pontine tumors may be diagnosed pneu-

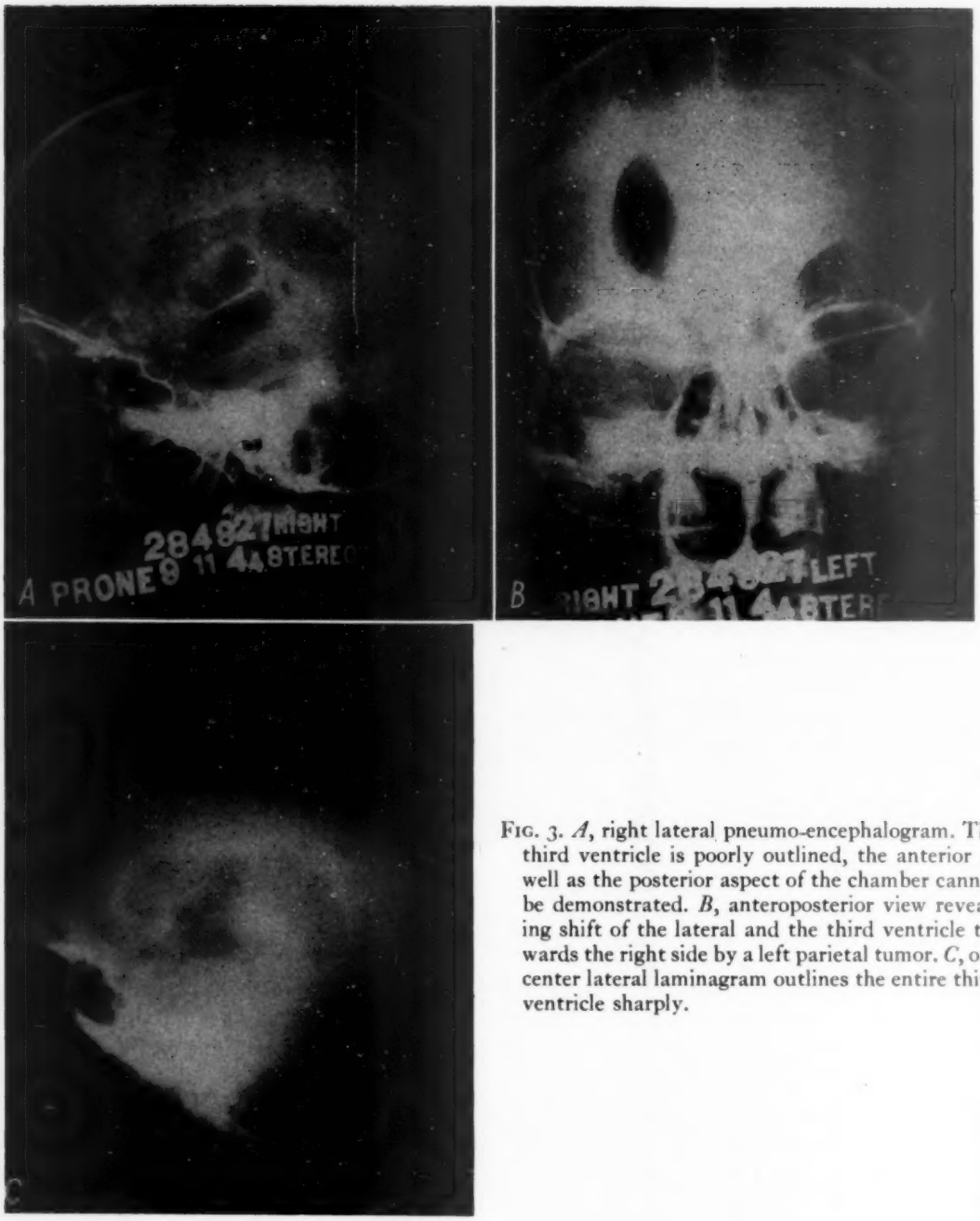

FIG. 3. *A*, right lateral pneumo-encephalogram. The third ventricle is poorly outlined, the anterior as well as the posterior aspect of the chamber cannot be demonstrated. *B*, anteroposterior view revealing shift of the lateral and the third ventricle towards the right side by a left parietal tumor. *C*, off-center lateral laminagram outlines the entire third ventricle sharply.

mo-encephalographically by dorsal displacement of the fourth ventricle and aqueduct and narrowing of the cisterna pontis as the result of a mass within the pons. From the roentgenographic viewpoint the diagnosis rests on adequate visualization of these structures.

Cerebellopontine atrophy results in an increase in the size of the neighboring cisterns. When present, it may be diagnosed because of the dilatation of these structures as represented pneumo-encephalographically.

RESULTS

During the past two years we have made laminagrams as part of our pneumo-en-

cephalographic examination in approximately 100 patients. Fifteen of these had tumors encroaching on midline structures, and these constitute the chief group for review. As a control the last 30 cases without evidence of midline involvement were reviewed for purposes of comparison. The remaining cases were not included.

There were 7 patients with cerebellar tumors, of which 5 were diagnosed microscopically as medulloblastomas, 1 as a meningioma springing from the tentorium above the superior lobule of the cerebellum, and 1 as a hemangioblastoma. There were 2 other patients with suprasellar meningiomas, 3 with Rathke's pouch tumors, and 1 with a dermoid tumor arising above the tuberculum sellae impinging into the third ventricle. One patient had a pontine tumor and another had a definite cerebellopontine atrophy. All these except for the patients with the pontine tumor and the cerebellopontine atrophy were confirmed at operation and by microscopic examination of the specimens.

The above 15 patients were considered in a group for the purposes of this study. Numerical analyses were made in which comparison of the findings on the routine pneumo-encephalograms and the laminagrams were reviewed. The structures we were particularly interested in were the third ventricle, the aqueduct of Sylvius, the fourth ventricle, the cisterna pontis and the cerebellum. The 7 patients with cerebellar tumors were examined by means of ventriculography, while the others had pneumo-encephalography by the lumbar route.

Table I

Controls—30 cases
Other Midline Lesions—8 cases
Cerebellar Tumors—7 cases

	Third Ventricle		Aqueduct of Sylvius		Fourth Ventricle		Cisterna Pontis		Cerebellar Sulci		
	Pneumo-encephalogram	Laminagram	Pneumo-encephalogram	Laminagram	Pneumo-encephalogram	Laminagram	Pneumo-encephalogram	Laminagram	Pneumo-encephalogram	Laminagram	
Controls	6	14	6	13	5	19	7	15	4	9	
Other midline lesions	1	5	1	5	2	7	2	2	0	6	*Well visualized*
Cerebellar tumors	2	7	1	4	2	5	2	4	1	4	
Controls	21	10	13	9	14	7	18	11	9	8	
Other midline lesions	6	2	4	2	4	1	3	4	2	1	*Fairly well visualized*
Cerebellar tumors	3	0	3	2	2	1	2	2	2	1	
Controls	3	6	11	8	11	4	5	4	17	13	
Other midline lesions	1	1	3	1	2	0	3	2	6	1	*Not visualized*
Cerebellar tumors	2	0	3	1	3	1	3	1	4	2	

The latest 30 cases without midline pathologic change were studied in a similar manner. In this group there were 11 patients who were examined by ventriculography. There were 12 patients with supratentorial tumors, and the others had no demonstrable lesions. For the purposes of this review all were considered negative from the viewpoint of midline or subtentorial disease.

There was an additional group of 7 patients with sphenoid bone changes and intracranial calcifications. Laminagrams in

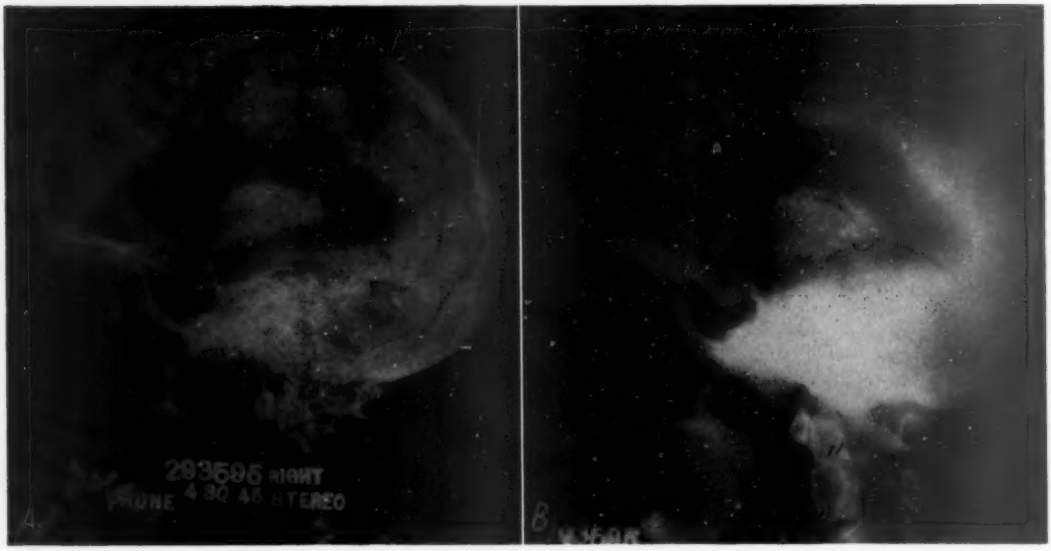

FIG. 4. Case 1. *A*, lateral ventriculogram shows dilatation of the lateral ventricles. The third ventricle and the upper aspect of the aqueduct of Sylvius can be outlined, while the fourth ventricle is not visible. *B*, the lateral midline laminagram portrays the third ventricle sharply. There is considerable dilatation in its anterior aspect, dipping towards the sella turcica. The upper aspect of the aqueduct is clearly visible. Narrowing of the cisterna pontis can be seen. The fourth ventricle could also be demonstrated on the original film, but is poorly seen here because of difficulty in reproduction. A meningioma springing from the inferior surface of the tentorium close to the midline was found at operation.

this group confirmed our previous opinion as to the importance of the procedure and will not be included here.

A review of Table 1 will demonstrate that although there are many cases in which no additional information may be derived from the laminagrams, nevertheless the visualization of the midline structures is almost consistently better on the laminagrams than on the routine examinations. This is particularly true of the posterior aspect of the third ventricle, the aqueduct of Sylvius, the fourth ventricle, the cisterna pontis and the cerebellar sulci. Visualization of the length of the callosal sulcus and the cingulate sulcus was frequent, and occasionally the calcarine fissures were well portrayed.

In an appreciable number of patients, particularly those with cerebellar tumors, we were able to visualize the third and fourth ventricles and the aqueduct of Sylvius sharply when the routine studies were either confusing or no filling could be demonstrated. The cisterna pontis was brought sharply in view in several patients with cerebellar tumors in whom the observation was considered of great diagnostic value. The importance of visualizing both the cisterna pontis and the fourth ventricle is apparent in the diagnosis of cerebellar and pontine tumors.

Case reports illustrating these observations follow.

REPORT OF CASES

CASE 1. M. L. (Hospital No. 281055), male aged thirty-five, had complained of intermittent headaches on both sides of his forehead for about one year, accompanied by nausea but no vomiting. When the headaches were more severe they spread over his head and the back of his neck. There was no blurring of vision.

Physical examination revealed early papilledema bilaterally, with fullness of the retinal vessels and tortuosity of the retinal veins. His blood pressure was 160/104. Examination otherwise was not noteworthy.

Routine lateral stereoroentgenograms and posteroanterior and anteroposterior roentgenograms of the skull revealed only slight sellar

atrophy suggesting the presence of increased intracranial pressure. Electro-encephalographic examination was reported as showing definite evidence of electrical abnormality affecting the left considerably more than the right side. The activity was too variable to permit any clinical deductions.

Ventriculography revealed uniform dilatation of the lateral ventricles without displacement from the midline. The third ventricle could be incompletely outlined, while the aqueduct and fourth ventricle were not definitely delineated on any of the ventriculograms. A midline laminagram clearly outlined the entire third ventricle, the aqueduct and the fourth ventricle. The anterior aspect of the third ventricle was markedly dilated, projecting down into the sella turcica. The aqueduct was dilated and displaced forward, while the fourth ventricle was smaller and likewise displaced forward. The cisterna pontis was narrowed. A diagnosis of a high cerebellar tumor close to the midline was made.

At operation a meningioma springing from the under surface of the tentorium towards the right side of the cerebellum was found and removed completely.

The patient made a satisfactory recovery.

Case II. I. B. (Hospital No. 284552), female, aged twenty-eight, complained of headaches, anorexia and nausea which had been progressive for about seven months. The headaches began in the occipital region and spread over the entire head. Blurring of vision started five months ago, and was more marked in the right eye. Diplopia had been present on two or three occasions in the past month. Immediately before admission she had difficulty in walking because of a wobbly gait.

Physical examination revealed her gait to be unsteady, with a slightly widened base. There was bilateral papilledema, with hemorrhages and exudates in the right eye. Nystagmus was present on right lateral gaze, and there was weakness of the right lower facial muscles.

Cerebrospinal fluid examination revealed the total proteins elevated to 262 mg. per 100 cc., globulin four plus. The colloidal gold curve was negative. The Wassermann reaction was negative.

Direct roentgenographic examination of the skull showed no bony changes. Ventriculography revealed a diffuse dilatation of the lateral ventricles without displacement. The third and fourth ventricles were faintly outlined and the cisterna pontis could not be identified. The

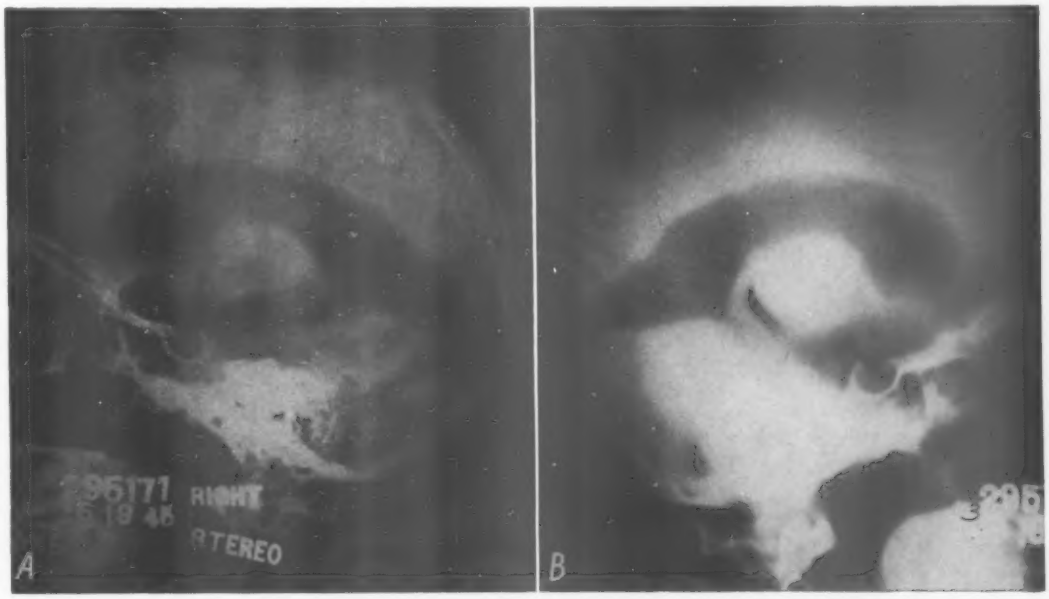

Fig. 5. Case II. *A*, lateral ventriculogram shows dilatation of the lateral ventricles. The third ventricle is visualized, but the aqueduct of Sylvius, the fourth ventricle and the cisterna pontis are not seen. *B*, the lateral midline laminagram clearly outlines the narrowed cisterna pontis. The superior portion of the aqueduct is seen displaced forwards. The fourth ventricle cannot be seen. At operation a cystic tumor of the right cerebellar hemisphere was found.

overlying air shadows and the mastoid cells made definite identification of the midline structures difficult.

The lateral midline laminagrams clearly identified the third and fourth ventricles, the aqueduct of Sylvius and the cisterna pontis. The forward displacement of the fourth ventricle, and the aqueduct, and the narrowing of the cisterna pontis were apparent and clearly diagnostic of a cerebellar tumor.

At operation a cystic tumor of the right cerebellar hemisphere was found. It was the opinion of the surgeon that the lesion was a cystic astrocytoma involving principally the upper lobe.

The patient made a satisfactory recovery.

CASE III. H. A. (Hospital No. 280061), female, aged ten, was admitted because of blurred vision of two months' duration, headache and vomiting. Examination revealed marked papilledema with secondary atrophy of the optic disks and marked diminution of visual acuity. Her head seemed larger than ordinary and a positive McEwen's sign was elicited. Her reflexes were diminished throughout.

The visual fields were negative except for a greatly increased blind spot. Routine roentgenograms of the skull revealed marked spreading of the sagittal suture and increased convolutional digital markings indicative of increased intracranial pressure. Electro-encephalographic examination revealed moderate diffuse deviation from the normal electrical expectancy for her age but nothing indicative of localized cerebral abnormality.

Ventriculography revealed a uniform dilatation of the lateral ventricles with no displacement to either side. The third and fourth ventricles were poorly outlined, and the aqueduct of Sylvius could not be clearly demonstrated. The cisterna pontis was poorly outlined. A midline laminagram in the lateral projection clearly outlined the third and fourth ventricles and the aqueduct. The third ventricle was dilated, the aqueduct was dilated and displaced slightly upwards. The fourth ventricle was dilated, and a tumor mass could be demonstrated projecting within the air shadow clearly diagnostic of a posterior fossa tumor encroaching into the fourth ventricle.

A suboccipital craniotomy was performed, and the partial removal of a fourth ventricle tu-

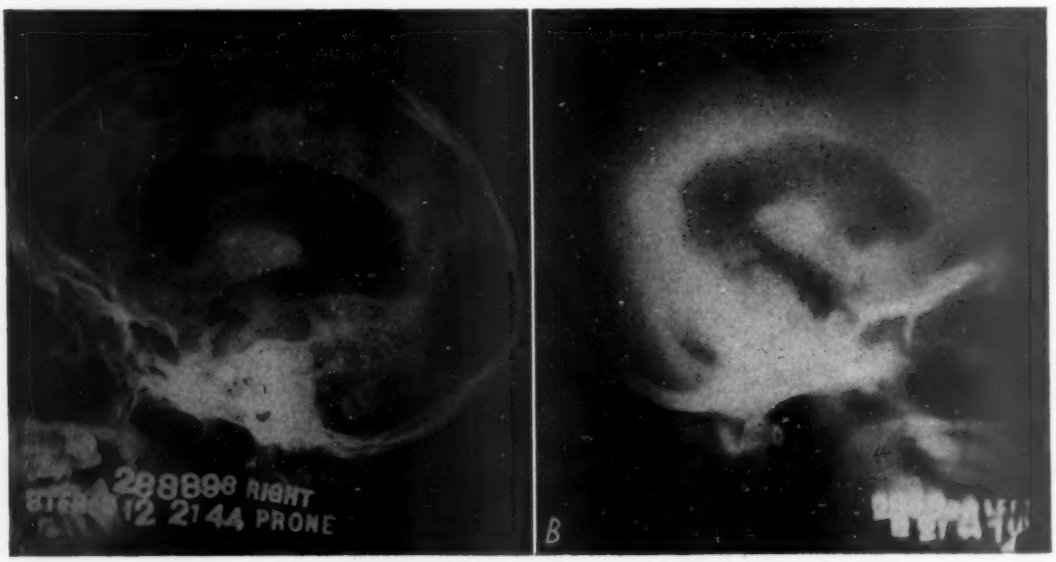

FIG. 6. Case III. *A*, lateral ventriculogram revealing dilatation of the lateral ventricles. The third ventricle can be outlined, but the fourth ventricle and the aqueduct of Sylvius are obscured. *B*, the lateral midline laminagram sharply outlines the third ventricle in its entirety. The aqueduct of Sylvius and the fourth ventricle are clearly portrayed. The aqueduct is dilated and shifted forwards and upwards. The fourth ventricle is dilated, and a large tumor mass springing from its floor protruding upwards and backwards is present. At operation a medulloblastoma was found.

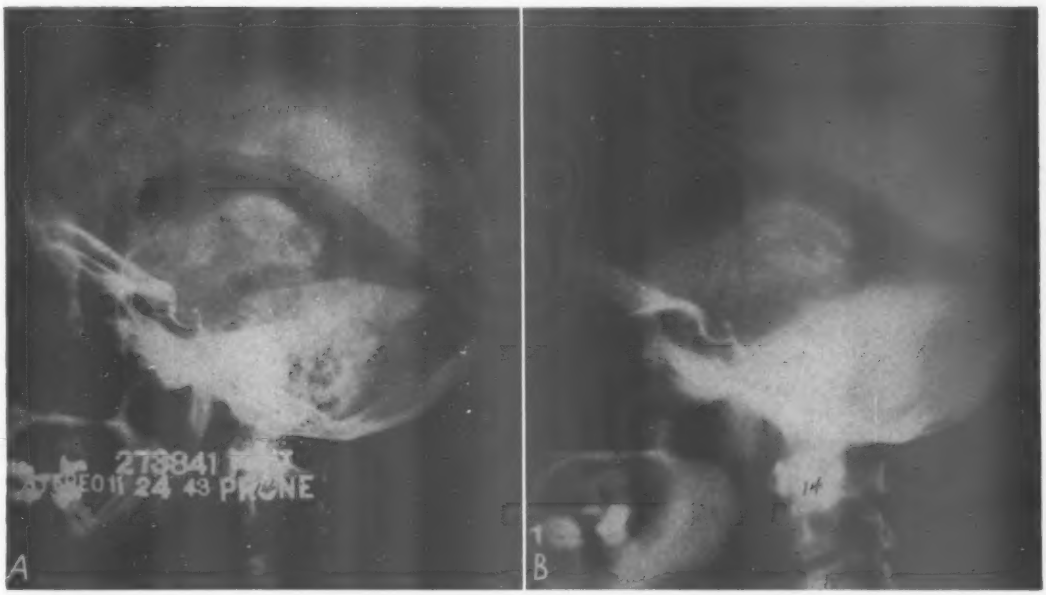

FIG. 7. Case IV. *A*, lateral pneumo-encephalogram reveals moderate dilatation of the lateral ventricles. The third ventricle can be outlined, and its anterior aspect is elevated. The aqueduct of Sylvius and the fourth ventricle cannot be seen. The tuberculum sellae is thickened. *B*, lateral midline laminagram sharply outlines the entire third ventricle. The aqueduct and fourth ventricle are visible. The elevation of the anterior aspect of the third ventricle is better visualized. The thickening of the tuberculum sellae likewise is better visualized. At operation a dermoid cyst springing from the vicinity of the optic chiasm was found.

mor extending through the foramen of Magendie was performed. The biopsy was reported as medulloblastoma.

The patient made a satisfactory postoperative recovery, and was subsequently given deep roentgen therapy. She remains in fairly good condition at the present time, about one year after operation.

CASE IV. M. C. (Hospital No. 270251), female, aged thirty-seven, noted double vision about six months before admission. She was told that she had bilateral optic atrophy and was hospitalized at another institution for one week, at which time examination and roentgenographic investigation were reportedly normal. She was given malarial therapy for one week without improvement. There was difficulty in seeing objects to either side. There had been occasional headaches related to a known sinusitis.

Physical examination revealed bilateral optic atrophy and bitemporal hemianopsia. Her visual fields were diminished in the nasal regions. There was middle ear deafness bilaterally, more marked on the right side, following mastoiditis eleven years previously.

The cerebrospinal fluid proteins were 35 mg. per 100 cc. The Wassermann reaction and colloidal gold curve were negative.

Roentgenographic examination of her skull revealed an increased density of the tuberculum sellae, with haziness of the anterior clinoid processes due to bony thickening.

Pneumo-encephalography after the injection of 95 cc. of helium outlined the lateral ventricles satisfactorily. The ventricular system was symmetrically dilated. The third ventricle, aqueduct of Sylvius and the fourth ventricle were fairly well seen on the encephalograms. The anterior portion of the third ventricle was elevated from below upwards. A lateral laminagram through the midline outlined the third ventricle much more clearly, and the elevation of its anterior inferior aspect was apparent. The visualization of the aqueduct and fourth ventricles was considerably better than noted on the pneumo-encephalograms. The thickening of the tuberculum sellae was sharply delineated.

The clinical diagnosis was a midline tumor

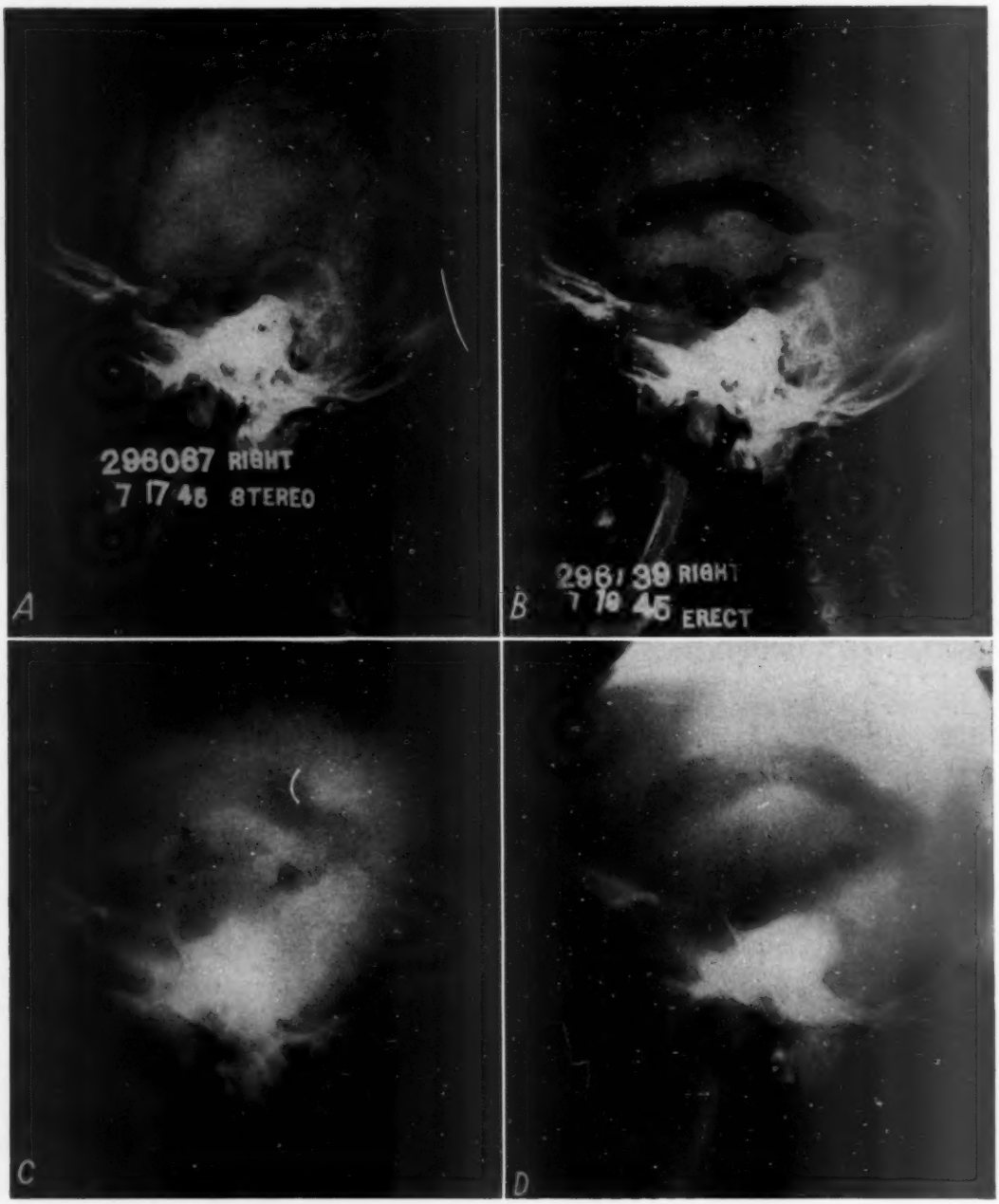

FIG. 8. Case v. *A*, lateral roentgenogram of the skull reveals atrophy of the dorsum sellae. The floor of the sella cannot be identified. *B*, lateral ventriculogram shows moderate dilatation of the lateral ventricles. A soft tissue mass protrudes into the cisternae chiasmaticus and interpeduncularis from the region of the dorsum sellae. The third and fourth ventricles are poorly outlined. The sella is the same as noted in *A*. *C*, the lateral midline laminagram reveals the fourth ventricle in its normal position. The third ventricle is not seen. The disappearance of the floor of the sella turcica is strikingly portrayed, and the soft tissue tumor occupying the sphenoidal sinus is readily apparent. The anterior wall and floor of the sphenoid bone are intact. *D*, off-center laminagram outlines the entire third ventricle and the upper aspect of the aqueduct of Sylvius. The fourth ventricle is not seen on this laminagram. A chromophobe adenoma of the pituitary was found at operation.

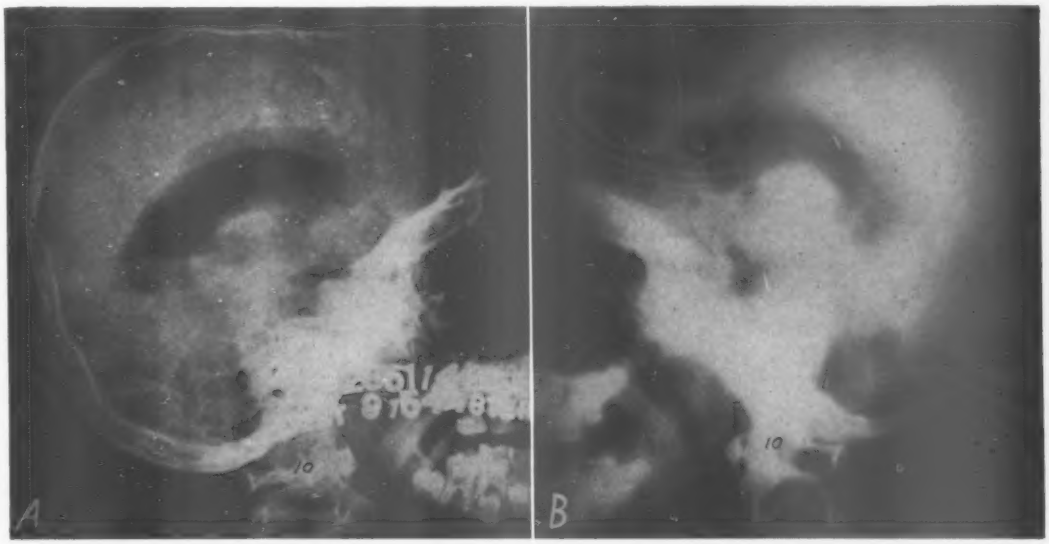

Fig. 9. Case vi. *A*, lateral encephalogram reveals dilatation of the entire ventricular system. The third and fourth ventricles are obscured by overlying shadows. *B*, lateral midline laminagram outlines the midline structures more clearly. Dilatation of the cisterna magna is well portrayed.

arising in the vicinity of the optic chiasm intruding into the anterior inferior aspect of the third ventricle.

At operation a yellow encapsulated tumor was found in the region of the optic chiasm extending to the right of the optic nerve. After breaking the capsule, white soft cheesy material could be removed in relatively large quantities. The tumor reached under the pons and appeared to vanish into the posterior fossa under the tentorium. The contents of the supratentorial part of the sac were removed with part of the capsule. The pathologic report was epidermoid cyst.

The patient made an excellent recovery and has returned to her occupation as a nurse.

Case v. L. B. (Hospital No. 285402), female, aged forty-three, complained of severe occipital headaches for twelve months. The pain radiated to the right temporal region. Diplopia and difficulty in vision with the right eye appeared two months earlier, together with nausea and vomiting. The headaches and diplopia, which were quite severe for about three weeks, then subsided gradually.

Physical examination revealed bilateral papilledema. The visual fields showed defects in the temporal half and nasal quadrant of the right field. There was diplopia on right lateral gaze, and weakness in abduction and elevation of the right eyeball.

Routine roentgenographic examination of the skull revealed a marked degree of atrophy of the posterior clinoid processes, the dorsum sellae and the floor of the sella. The pineal shadow was not visible.

Routine ventriculograms showed the lateral ventricles to be moderately dilated but not shifted from the midline. A soft tissue tumor mass protruding into the cisternae chiasmaticus and interpeduncularis could be demonstrated, extending above the sella approximately to the level of the posterior clinoid processes. The third ventricle was faintly outlined and the aqueduct of Sylvius and the fourth ventricle were barely visible.

A central lateral laminagram and laminagrams 0.5 cm. to either side of the midline revealed the third and fourth ventricles clearly and sharply. The elevation of the anterior aspect of the third ventricle was apparent, and destruction of the floor of the sella turcica with a soft tissue tumor mass protruding into the sphenoidal sinus was clearly delineated.

At operation a gelatinous tumor was found in the region of the optic chiasm. Intrasellar aspiration of the tumor failed to yield fluid. The outer layer of the mass was coagulated and there was partial intracapsular removal of the

tumor. Microscopic examination revealed a chromophobe adenoma of the pituitary gland.

The patient made a satisfactory postoperative recovery.

CASE VI. R.D. (Hospital No. 277767), female, aged nine, was a full term, normally delivered child whose development was average up to the age of five years, when her first convulsion occurred. The aura consisted of a feeling of stiffness in her left forearm followed by a spasm which flexed the left hand. There was no loss of consciousness, falling or pain. The convulsions lasted about two minutes and occurred about once in three months. She also complained of headaches localized to the right supraorbital ridge.

Physical examination revealed a bilateral positive Babinski sign and slight nystagmus on lateral gaze.

Routine roentgenographic examination of the skull was negative. Pneumo-encephalography revealed diffuse cerebral and cerebellar atrophy as evidenced by the dilatation of the entire ventricular system. The lateral midline laminagram portrayed the dilatation of the third and fourth ventricles, the aqueduct of Sylvius and the cisternae pontis and magna more sharply than the routine encephalograms.

This was considered a non-operative condition and the patient was discharged from the hospital.

SUMMARY AND CONCLUSIONS

The use of laminagraphy with pneumo-encephalography is discussed from the viewpoint of the diagnosis of midline and posterior fossa tumors, with special reference to visualization of the third and fourth ventricles, the aqueduct of Sylvius, the cisterna pontis and the cerebellar sulci.

The proportion of visualizations of these structures is increased by the addition of laminagraphy to the usual pneumo-encephalographic techniques. In an appreciable number of patients visualization was sufficiently improved so that definite diagnostic conclusions could be reached which otherwise might be doubtful or overlooked. In others the midline structures could be visualized on the laminagrams and not on the pneumo-encephalograms.

Laminagraphy is recommended as a routine procedure in pneumo-encephalography when visualization of the midline structures is necessary.

REFERENCES

1. ALEXANDER, G. H. A simple and inexpensive tomographic method. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *39*, 956–958.
2. CARRILLO, R., ORIBE, M., and MALENCHINI, M. Tomo-encefalografía. *Semana méd.*, 1937, *2*, 472–477.
3. DYKE, C. G., and DAVIDOFF, L. M. Pneumo-encephalographic appearance of hemangioblastoma of the cerebellum. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *44*, 1–8.
4. EPSTEIN, B. S. Skull laminagraphy. *Radiology*, 1942, *38*, 22–29.
5. EPSTEIN, B. S. Laminagraphy of the sphenoid bone. AM. J. ROENTGENOL. & RAD. THERAPY, 1942, *48*, 625–631.
6. HOLVEY, E. H., ROSENTHAL, L. M., and ANSON, B. J. Tomography of the skull. *Radiology*, 1945, *44*, 425–448.
7. KIEFFER, J. The laminagraph and its variations. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *39*, 497–513.
8. KIEFFER, J. Analysis of laminagraphic motions and their values. *Radiology*, 1939, *33*, 560–585.
9. LUTZ, W., and TURNER, O. Planigraphic studies of ventricular system; fourth ventricle and adjacent structures. *Yale J. Biol. & Med.*, 1940, *12*, 399–405.
10. LYSHOLM, E. Das Ventrikulogramm. I. Röntgentechnik. *Acta radiol.*, 1935, suppl. 24.
11. OLIVECRONA and LYSHOLM. Quoted by Twining.[15]
12. PETERSON, H. O., and BAKER, A. B. Difficulties in differentiating midbrain lesions from cerebellar lesions. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 37–51.
13. TAYLOR, H. K. Planigraphic examination of the thorax in tuberculous individuals. *Quart. Bull., Sea View Hosp.*, 1938, *3*, 357–374.
14. TURNER, O., and LUTZ, W. Planographic studies of the fourth ventricle; preliminary report with illustrative case. *Yale J. Biol. & Med.*, 1940, *12*, 251–253.
15. TWINING, E. W. Radiology of third and fourth ventricles. *Brit. J. Radiol.*, 1939, *12*, 385–418; 569–598.

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OPAQUE MYELOGRAPHY IN PENETRATING WOUNDS OF THE SPINAL CANAL*

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INTRODUCTION

PENETRATING wounds of the spinal cord and cauda equina are common in this war and present certain serious problems. Patients with such injuries are greatly incapacitated, require careful and protracted nursing care, and in spite of all supporting therapy the prognosis is unfavorable. Not the least of the difficulties is the establishment of an accurate anatomical diagnosis.

Before the present war no one had an opportunity to study the myelographic appearances produced by spinal wounds. Our own experience in myelography was formerly limited to prolapsed intervertebral discs and a few tumors and infections of the spinal cord and cauda equina.

Our first myelogram on a paralyzed patient was prompted by curiosity. We had reason to believe that the cord had been transected by a rifle bullet. The patient faced a depressingly poor prognosis and we wished to secure some "interesting films." To our gratification, however, an epidural abscess was found to be the true cause of the symptoms and after surgical drainage the patient regained the use of his limbs. Following this, the procedure became a valuable and dependable one in the handling of our patients.

Doing myelograms on patients who are paralyzed, incontinent and in many cases ill from other wounds is time consuming, difficult and considerably wearing for both the patient and the examiner. In our hospital (a neurosurgical center), however, it has been found so useful in localizing and analyzing the lesion and so dependable as a guide to operation or re-operation that we regard myelography as justifiable and highly desirable. It should most surely be done before relegating a patient to the "too late to do anything" category.

When we began our myelographic studies on wounded soldiers our experience was most inadequate and we made many mistakes in interpretation. Thirteen of the patients on whom we did myelograms were operated upon at this hospital and we are therefore able to review and correlate the roentgen findings with the surgical findings in this group. One patient died and the postmortem findings are available.

This presentation it is hoped will be found useful to roentgenologists. It is based upon our errors and what we have learned, and it is our belief that it may contribute to greater diagnostic accuracy in future examinations. We have purposely omitted detailed neurological and neurosurgical material as such will be separately reported in suitable form. Many patients were operated upon at our hospital without myelography, and myelograms were made on patients not operated upon. In the present report we include only the 13 cases which had both myelography and operation.

PURPOSE

It is the purpose of this paper:

1. To stress the value and dependability of opaque myelography in the evaluation of and as a guide for the management of patients with penetrating wounds of the spinal canal.

2. To describe and illustrate certain abnormalities in the roentgen myelographic picture which we have found associated with surgically proved lesions of the cord and cauda equina.

3. To offer some suggestions pertaining to the interpretation of myelograms in patients of this kind.

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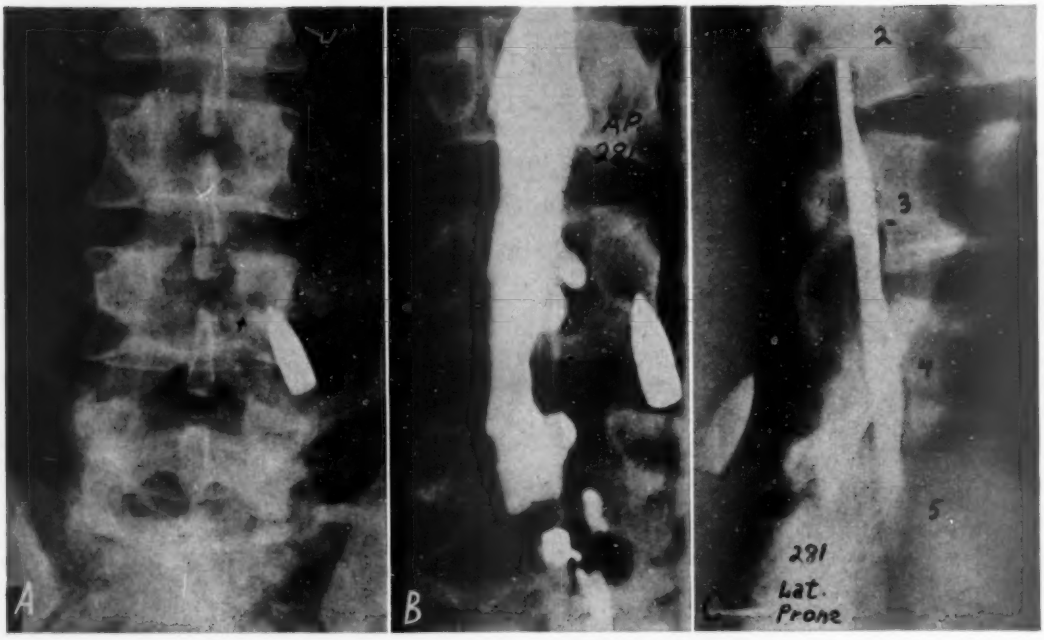

FIG. 1. Case 1. Example of a clear cut, sharply marginated indentation. *A*, the bullet is in the muscles of the back. Arrows indicate multiple hair line fractures of the left lamina of L4 and left transverse process. *B*, anteroposterior view of oil showing the defect opposite the fractured lamina at the level of the disc between L4 and L5. *C*, lateral view. Patient prone. There is no ventral indentation of the oil column. Note that the oil does not outline the dorsal margin of the neural canal in the prone position.

4. To emphasize some points in myelographic technique which may prove helpful to others doing work of this nature.

Retrospective analysis of the myelograms in our series permits certain didactic breakdown of the deviations from normal. We do this in order that the analysis of future myelograms may be simplified. While each patient's case is frequently unique, the major myelographic abnormalities encountered can be classified in one of the following categories for purposes of discussion. We must point out at this time that the following abnormalities are commonly found in various combinations with each other, rather than in pure or uncomplicated forms.

CATEGORIES OF DEFECTS FOUND AFTER INJECTION OF OIL

1. Sharply localized, clearly marginated indentation.
2. Angulation.
3. Extra-arachnoid oil.
4. Displacement.
5. Feathery irregular filling defects.
6. Altered physical characteristics of the oil.
7. Complete subarachnoid block.

1. *Clearly Marginated Indentation.* A sharply marginated, localized, clearly outlined indentation of the oil column, such as is well illustrated in Figure 1, indicates localized external pressure on an intact dura. This defect is almost identical with the well known defect produced by uncomplicated posterior or lateral protrusion of the intervertebral disc, although of course in our cases it is not necessarily at a disc level. It may be dorsally, ventrally or laterally located.

This type of defect in our series has always been found associated with fractures of and loose bone chips from the laminae (posterolateral position) or one pedicle (lateral defect). Hermorrhage, infection, and foreign bodies have not produced de-

fects of this type. We have not as yet seen such a typical defect situated anterior to the cord or cauda, although a shatter fracture of a vertebral body might give rise to a small bone fragment which would produce the picture by indentation of the dura from its ventral aspect.

Defects of this variety carry a good prognosis and may be expected to disappear completely after removal of the bone fragment even months after the injury (see Diagram 1).

This defect is most frequently found on the dorsal aspect of the neural canal and if near the midline may well be overlooked unless oblique or supine projections are utilized.

Diagram 1. This and the following cross sectional diagrams are offered to illustrate the myelographic abnormalities described in the text. They depict our conceptions of the three-dimensional anatomy disclosed by myelography and operation. The diagrams are of necessity combinations of fact and hypothesis. They represent reconstructions after operation and review of each case. For convenience, the patient is always shown in the prone position (pantopaque in the ventral portion of the subarachnoid space) and the dura-arachnoid is represented by a single heavy line.

The following abbreviations pertain to all diagrams: *EP.S.*, epidural space; *D.A.*, dura and arachnoid; *C.F.*, caudal filaments; *N.R.*, nerve root; *P.*, pantopaque; *C.S.F.*, cerebrospinal fluid; *SP.C*, spinal cord.

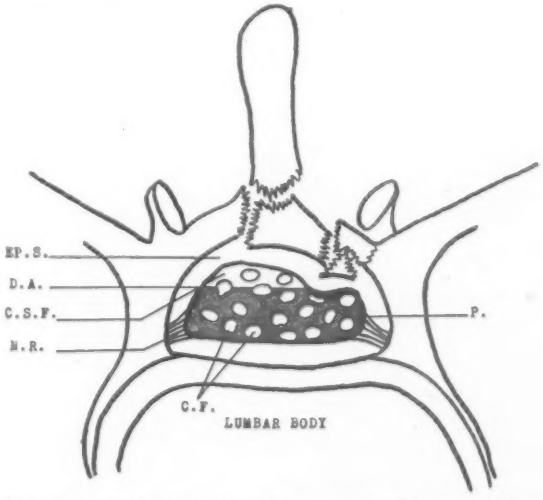

Diagram 1. *Indentation.* Fragments of bone, arising from fractures of the base of the spinous process and the left lamina, indent the dura-arachnoid and crowd the caudal filaments together (see Case 1, Fig. 1*B*).

2. *Angulation.* Angulation of the column requires no definition. It is readily recognized following some through and through wounds of the dura. The defect, we believe,

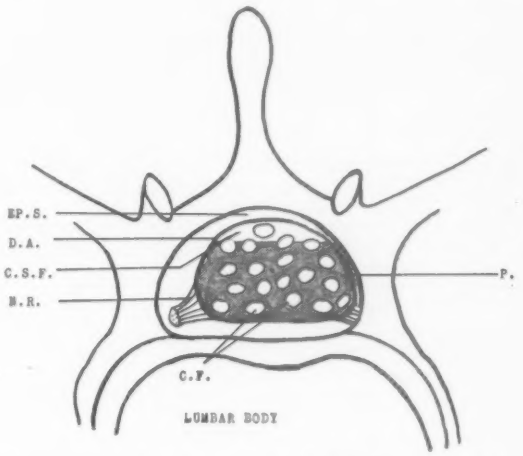

Diagram 2. *Angulation.* The right lumbar root has been severed and the dural tube is pulled to the left by epidural scar tissue, thus producing angulation of the oil column as seen in the anteroposterior view (Case XIII, Fig. 13*B*).

is the result of scarring and contraction of the dura and epidural soft tissues in the axis of the missile tract. Another factor in the production of the angulation is traumatic unilateral severence of the nerve roots and the dentate ligament which normally stabilize the dural tube. This is illustrated in Case XIII. The metal fragment passed from left to right cutting the nerve root on the left and producing angulation of the oil column with convexity toward the right along the path of the missile (see Fig. 13*B* and Diagram 2).

3. *Extra-arachnoid Oil (near the lesion).* Extra-arachnoid oil is all too frequently encountered as the result of faulty technique. If the entire needle point is not in the subarachnoid space alone when the injection is made, the oil flows also into either the subdural or the epidural spaces and serves to obscure the field. Epidural oil is sometimes mistaken for subarachnoid oil even by careful roentgenoscopists, although the

TABLE I

CONDENSED CASE REPORTS

Case No.	Level of Lesion	Projectile	Wound Entry	Wound Exit	Interval Wound to First Operation (Forward Area)	First Operation (Forward Area)	Interval Injury to Myelogram (days)	Neurological Findings at Time of Myelogram	Plain Roentgenograms, this Hospital, Time of Myelogram	Level of Needle
I	L_4, L_5	Rifle bullet	Left flank	0	Same day	Repair bowel perforations. Control intra-abdomen and retroperitoneal hemorrhage	41	Paralysis left lower extremity. Hyperesthesia and hypalgesia ant. left leg	Bullet in back muscles L Fracture trans. process L Fractures (hair line) l lamina L_4	L_5
II	L_1, L_2	Rifle bullet	Rt. buttock	0	43 days	0	40	Weakness left lower extremity. Atrophy leg muscles. Reflexes diminished left. Bladder urgency and rectal sphincter relaxed	Bullet in center of neu canal at L. Shatter fractu right lamina and pedicle L2. Fractures trans. pro esses L2, 3, 4 on right	L_4
III	L_4	High explosive fragments	Rt. chest and rt. low back	0	Same day	Debridement and laminectomy lumbar region. Described partial section of cauda at L_5	51	Bilateral foot drop. Posterior tibial groups atrophied. Rt. quadriceps paralyzed. Bilateral loss knee and ankle jerks. Bilateral sciatic nerve anesthesia	L_4 badly shattered. La inectomized L_3, 4 and Missile tract through la inae, pedicles and neu canal at L_4	2 nee dles) L_1 S_1
IV	L_2	High explosive	Rt. loin back and chest	0	1 day	2 × 2 × 6 cm. metallic foreign body removed from inside dura at L_2. Several caudal roots found cut	29	Complete motor and sensory loss below L_1 bilaterally. Cystostomy	Laminectomy L_2. Fra tures both pedicles a body L_2. Fracture rt. 1 rib and rt. trans. proc. L	L_5
V	L_3	Rifle bullet	Rt. loin	L. lumbar	1 day	Suture liver, duodenum, rt. ureter and colon	35	Left foot drop. Atrophy left thigh and leg. Focal weakness rt. leg and foot. Reflexes absent both legs. Anesthesia in segments S_2, 3, 4 lt. anesthesia L_2	Fracture left trans. p L_3; fracture left pedicle L_3?	L_5
VI	L_3	High explosive	Face, chest, arm and back	0	1 day	Colostomy, debridement, enucleation of eye (no laminectomy)	77	Rt. paresis quadriceps group, absent K. J. Hyperesthesia L_3 dermatome	Metallic foreign body × 14 × 7 mm. in vertel body at level of disc L_3, This protrudes into the n ral canal at rt. ventral pect	S_1
VII	T_2	Rifle	Lower left ant. neck	Rt. back near T_3	20 days	None; see surgical findings, this Hospital	18	Loss of sensation and motion below neck from onset. Partial recovery in arms in last week before operation	Shatter and penetrat fractures laminae and s nous process T_2. Fract body T_2?	L
VIII	T_1, T_2	High explosive	Lower left neck	0	5 days	Attempt at laminectomy abandoned as patient stopped breathing	49	Complete paralysis and loss of sensation below T_1	11 mm. metallic for body behind and to righ neural canal at disc le T_1–T_2	L

TABLE I.—*continued*

Level of Needle	Hydrodynamic Study	Spinal Fluid	Myelographic Summary	Surgical Findings (Abbreviated) this Hospital	Length of Post-operative Follow Up	Result, Early Follow Up
L5	Normal	Clear; 6 lymphocytes; 99 mg. per 100 cc. protein	Clearly marginated indentation left at L4. Dorsal surface	Dura compressed and indented by bone fragments of fractured left lamina L4	4 wk.	Walking. Still has foot drop (left) and small area of hyperesthesia left ankle
L4	Complete block	Zanthrochromic. Pressure 110; 18 lymphocytes; pellicle; protein 649 mg. per 100 cc. Globulin 2+. Oil and cerebrospinal fluid mixture opalescent	Complete block at L1	Dura torn on rt. at L2. Dura thickened. Conus stopped at T12. Adhesive arachnoiditis of filaments of cauda. Complete block at L1. Filaments separated to find and remove bullet	8 wk.	Complete recovery. Complication: small pulmonary infarct 4 days postop. Ligation left femoral vein
(2 needles) L1	Normal	Clear. Cells −1. Protein 40 mg. per 100 cc.	Complete block from L3 to L5 for distance 7.5 cm.	Very marked scarring, epidural space. No continuity of dura found. Fliaments of cauda imbedded solidly in cicatrix. No cerebrospinal fluid present below scarring at L4	1 wk.	No improvement except for return of sensation as far down as mid calves
S1	Pressure 0. Complete block	Yellow, clotted at once, only 3 cc. obtainable				
L5	Complete block	Yellow, clotted	Block caudad to site of previous laminectomy	Large epidural abscess at L2 and L3. Paraspinal abscess to right of L2 containing woolen clothing	4 wk.	Developed renal hemorrhage (bullet tract traversed rt. kidney) and perirenal abscess; 3 days postoperative partial recovery of sensation of limbs; 2 months postop.: letter from patient states that he "can use his legs." No adequate follow up
L5	Normal	Clear; 1 lymphocyte; protein 73 mg. per 100 cc.	Clear cut defect anterolateral margin on the lt. at L3 oil in droplets	On the lt. at L3 the dura was blue and adherent to the cauda. Beneath dura was organizing blood clot and tissue reaction producing localized adhesive pia-arachnoiditis	3 wk.	Thigh muscles strong. Leg muscles all functioning but weak. Left toe drop still present
S1	Normal	Clear; no cells; protein 114 mg. per 100 cc.	Column constricted and indented adjacent to foreign body. Slight "feathering" of localized arachnoiditis	Foreign body in body lower margin L3; 3rd lumbar root compressed, dura indented. Foreign body removed. Bits of clothing about foreign body. No gross abscess. Dura not opened	4 wk.	Regained strength in involved muscle groups. Sensation normal except for small area hyperesthesia rt. lateral thigh. Decubitus healed
L3	Normal	Clear; 7 lymphocytes; protein 28 mg. per 100 cc.	Clear cut indentation on right T2 and T3	Body T2 comminuted and bone fragments impressed and depressed dura at T2 on right. Dura not opened appeared normal after removal of bone fragments	1½ wk.	Moved legs 3rd postoperative day. Moved both arms at 1 week. No pain. Transferred early for administrative reasons
L3	Normal	Clear; pellicle formed; protein 32 mg. per 100 cc.	Subarachnoid space obliterated on right T1 and T2. Oil puddle extra-arachnoid at T2 and T3. Droplet formation	Dura perforated and scarred. Dense cicatrix dura to cord on the right. Spinal medulla soft and necrotic T1 and T2. Diag.: Transection of cord	4 da.	Died 4th postoperative day. Repeated massive collapse of lung. Extensive necrosis of thoracic cord, fracture of vertebral body T1; dura perforated and granulating

Case No.	Level of Lesion	Projectile	Wound Entry	Wound Exit	Interval Wound to First Operation (Forward Area)	First Operation (Forward Area)	Interval Injury to Myelogram (days)	Neurological Findings at Time of Myelogram	Plain Roentgenograms, this Hospital, Time of Myelogram	Level of Needle
IX	T6, T7	High explosive	Several wounds back	0	22 days	None; see surgical findings, this Hospital	21	Complete paralysis below T8. Anesthesia below T5. Incontinence. Decubitus ulcer	Penetrating and shat fractures rt. lamina a spinous process T7 a T8. Metallic foreign bo 10×5 mm. anterolateral neural canal at T8	L4
X	L1	Rifle	Left lower chest	0	1 day	Removed bullet from right paraspinal soft tissues. No laminectomy	7	Flaccid paraplegia and sensory level below T10. No sacral sparing. Urinary retention	Fractures both laminae a spinous process of L1	L4
XI	T12	High explosive	Rt. shoulder through rt. chest	0	1 day	Laminectomy T8, 9, 10, 11 (1 segment cephalad to foreign body)	19	Causalgic pain rt. leg. Weakness rt. thigh, leg and foot. Deep reflexes absent. Hyperesthesia rt. below L1 with relative sacral sparing	Laminectomy T8 to T Fracture posterior marg of body of T12 and rt. i artic. facet of T11 on also laminae T11. Meta foreign body remains T1	L4
XII	L4, L5	High explosive 28 ×15×10 mm. fragment	Above rt. iliac crest	0	Same day	Removal foreign body. Local laminectomy and removal of bone fragments	20	Atrophy and paresis rt. thigh and leg and rotators of thigh. Hypalgesia rt. foot and lower leg. Rt. leg reflexes absent	Posterior elements L4 fr mented and some missi At least one bone fragm in neural canal at level L4–5 disc	L3
XIII	L1, L2	High explosive 16 ×10×10 mm. fragment	Low back	0	1 day	Debridement; removed spine of L2; no laminectomy	17	Paralysis rt. lower extremity. Weak extension left knee. Deep reflexes absent below waist bilaterally. Hyperesthesia and hypalgesia rt. thigh, leg and foot	16×10×10 mm. metall foreign body in left poste lateral quadrant of body L2. Fracture rt. inf. art process of L2. Spinous pro ess of L2 is missing	L5

differentiation should always be made (see Technique).

The myelographic finding to which we refer here is different from the artefactual one resulting from faulty injection. Here oil is placed in the subarachnoid space in the low lumbar region and runs freely in this space up to the level of the lesion. The oil then appears outside the expected limits of the subarachnoid space. The obvious explanation is that the oil runs out of the thecal space through a hole or tear in the arachnoid. In practice, when the arachnoid is torn the dura is always torn and the oil is able to reach an extradural situation. In our cases the escaping oil has never flowed freely into any other space but has only outlined a blind pocket of some sort. The myelographic appearance is essentially that of an extra-arachnoid "puddle," an oil-filled diverticulum or a short sinus, the long axis of which is parallel with that of the neural canal (Fig. 2*D* and 9*B*).

The meninges are notably rapid in proliferation and healing by gliosis. (Surgically produced rents in the dura quickly close over and seal in the spinal fluid.) Traumatic tears presumably heal by gliosis and granulation tissue provided by the cells in the epidural space. The "puddles" of oil are

Level of Needle	Hydrodynamic Study	Spinal Fluid	Myelographic Summary	Surgical Findings (Abbreviated) this Hospital	Length of Postoperative Follow Up	Result, Early Follow Up
L4	Normal	Clear; 2 lymphocytes; protein 30 mg. per 100 cc.	External compression at T7 on right. Oil "puddle" dorsal surface at T6	Fractures confirmed. Lamina of T7 was depressed severely. Dura and cord normal at T9 and 10. Dura not opened at T7. Compression by lamina removed	2 wk.	Beginning paresthesias both legs. Weak muscle contractions both thighs
L4	Sluggish at 20 mm. Normal at 40 mm.	Amber; 9 lymphocytes; protein 90 mg. per 100 cc.; oil settled slowly in spinal fluid	Swollen conus T12 and L1. Dorsal compression of neural canal at L	Laminae comminuted and adherent to dura. Dura ischemic, edematous and not pulsating. When dura opened the cord bulged and was edematous and contused. Dura not closed	4½ wk.	Slow improvement; 3 weeks postoperative had faint voluntary contractions of quadriceps and biceps femoris, bilaterally. Letter states he "uses his legs." No adequate follow up
L4	Sluggish rise at 20 and 40 mm. Normal rise at 60 mm.	Xanthochromic; cells 0; protein 30.4 mg. per 100 cc.	Slight dorsal displacement of ventral margin at T11. Indentation from rt. side at level of foreign body which is extradural	Bone chip at T12 was indenting dura ventral aspect. This and metallic foreign body removed. No abscess. Some old hemorrhage found anterior to dura at T11	4 wk.	Sensation normal. Able to walk, hop, jump and step over 24 inch obstacles
L3	Normal	Cloudy; cells 0; protein 140 mg. per 100 cc.	Indentation from rt. posterolateral aspect L4 and L5. Narrow irregular column L4 and 5 showing tortuosity and compression from dorsum	Large epidural abscess L4 and L5 about several loose bone fragments (largest 1 ×2 cm.). Dura not opened, but appeared pulseless and contused especially at L4	5 wk.	Rt. quadriceps, adductors, abductors and hamstrings improved considerably. Pain in rt. leg and foot. Hyperesthesia disappeared
L5	Slow responses at 20, 40 and 60 mm. mercury	Slightly yellow; 22 white cells, 86 per cent polys, 14 per cent lymphs; protein 120 mg. per 100 cc.	Angulation of column toward the left at L2. Posterior displacement of the column at L2, 3 and 4	Abscess (epidural and in the vertebral body) found about foreign body; also bits of clothing. Dura not opened. The entire dural tube was displaced by an extradural hematoma from L2 to L4. Rt. 1st lumbar root was found destroyed	1 wk.	Sensation normal except L1 dermatome. Moves right toes. Controls bowels and bladder. Normal muscle function left side

attributed to the remaining defects from healing tears of the meninges. When the oil discloses a diverticulum-like contour one may liken it to a localized traumatic myelocele into the epidural space (see Diagram 3). Theoretically if one were to do a myelogram on a patient very soon after the tearing of the dura and arachnoid, one would expect to find the oil flowing freely into the subdural and epidural spaces. We have never done a myelogram earlier than seventeen days following the injury at which time healing of the meninges is presumably far advanced and the oil merely settles into the pockets described above. In only 1 operated case has pantopaque been placed in the subarachnoid space and recovered from the epidural space.

Case VIII had the oil injected in the lumbar region and showed extra-arachnoid puddling in the high thoracic region on myelography. Operation and necropsy confirmed the presence of perforation of the dura and transection of the cord. There was granulation about the hole in the dura and arachnoid but oil was found in the epidural space showing communication between the subarachnoid and epidural spaces forty-nine days after the penetrating wound. In

this case the healing was evidently overshadowed by the necrosis (Fig. 8*D*).

4. *Displacement of the Column of Oil.* Displacement of the oil column is occasionally encountered. The arachnoid contents may

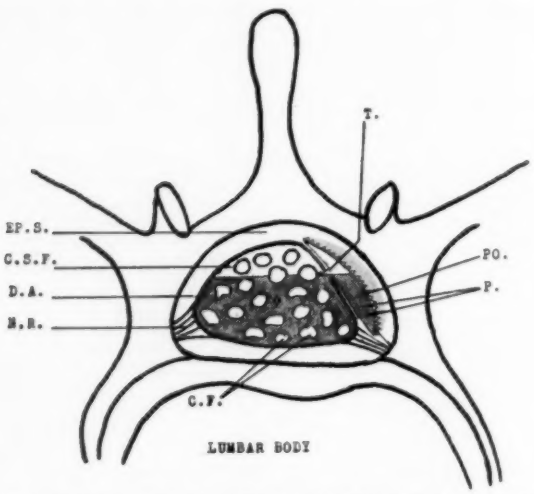

DIAGRAM 3. *Extra-arachnoid oil.* The tear (*T*) in the dura-arachnoid is not sealed and the oil and the cerebrospinal fluid fill a walled-off pocket in the epidural space (see Fig. 2*D* and 9*B*).

be displaced either ventrally or dorsally for several millimeters by anything (usually semifluid) which fills the subdural or epidural spaces in a "layered" manner. This abnormality may be overlooked, as in pure displacement there is no angulation, block or irregularity of the margins of the oil column. The oil column is merely found to be farther from the bony wall of the neural canal than normal. An analogous finding in another part of the body is the familiar anterior displacement of the airway in retropharyngeal abscess.

Normally as seen with the horizontal ray in the prone position the oil is not more than 2 mm. from the posterior margins of the vertebral bodies which comprise the anterior wall of the neural canal. The posterior wall can be seen only with the patient supine.

Anterior or posterior displacement of the cord or cauda has been found in our series only in the presence of blood or blood clot between the dura and the bony neural canal. It has not occurred in fracture or meningeal tear. Lateral displacement without angulation has not been found. This is attributed to the side-to-side fixation of the cord by the nerve roots with their dural coverings, the dentate ligaments and other (unnamed) delicate connective tissue strands between the dura and the walls of the neural canal. Anatomically there are no structures holding the dural tube to the posterior wall of the neural canal. Anteriorly fibrinous prolongations of the dura fasten it more or less securely to the longitudinal ligament.

This finding is illustrated in Figure 13*C*. Here the myelographic appearance induced the surgeon to explore anterior to the dura and to go more caudad than he would otherwise have done. The displacement was caused by a large organizing hematoma just anterior to the dura (Diagrams 4 and 6).

5. *Feathery Irregular Filling Defects (localized partial obliteration of the subarachnoid space).* Frequently, due to localized

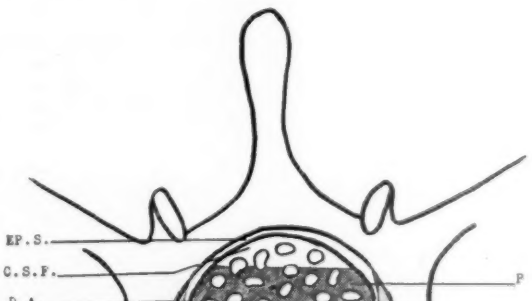

DIAGRAM 4. *Displacement.* Here a large extradural hematoma (*HEM*) lying ventral to the cauda equina produces dorsal displacement and compression (see Fig. 13*C*).

obliteration of the subarachnoid space, the oil is prevented from distributing itself evenly or completely about the spinal cord or the fibers of the cauda equina. This uneven spread of the oil produces very strik-

ing abnormalities in the myelographic picture. These are occasionally mistaken for evidences of extrinsic pressure.

The myelographic appearance is that of single or multiple irregular "feathery" filling defects within the oil column. The filling defects are ovoid, sausage shaped or branched, but their margins are "feathery" rather than clear cut, and the oil dispersed between them produces a pattern not conforming to any anatomical structures. The long axes of the defects, as well as the fimbriated oil strands between them, are parallel to or (in the lumbar region) slightly oblique to the long axis of the spinal cord.

When such an oil-deficient area is present near the dural surface or involving the dura, it can be seen in profile on appropriate oblique projection. The profile view is somewhat similar to that seen in broad based polyps in the gastrointestinal tract. The angle between the defect and the almost straight border of the subarachnoid oil column is acute (as contrasted with the externally produced pressure defects described above).

Discussion. Normally the spinal fluid completely surrounds the cord in the cervical and thoracic regions (Diagram 7) and fills the interfilamentous spaces between and among the fibers of the cauda equina in the lumbar region. When for any reason the pia and arachnoid become adherent, or the caudal filaments become agglutinated, then the cerebrospinal fluid (and likewise the opaque oil) cannot penetrate into these spaces. This produces the above described peculiar filling defects within or at the margins of the oil column.

At surgery one finds the so-called "pia-arachnoiditis" either hemorrhagic (more or less acute) or adhesive (chronic). In either case the arachnoid is found bound to the underlying pia of the cord or covering the caudal filaments. In the lumbar region, where this myelographic appearance is most frequently seen, the individual filaments are found agglutinated together by delicate adhesive strands. These are readily separated by "combing" or blunt separation but are strong enough to prevent the oil and spinal fluid from flowing between the filaments (Diagram 5).

One must point out that this obliterating local lesion is basically the same as that

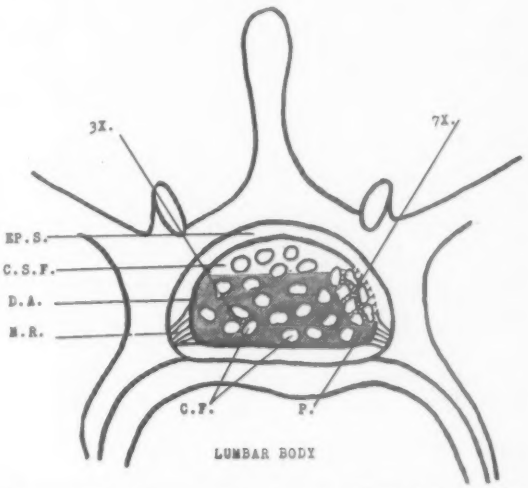

Diagram 5. *Feathery irregular filling defects.* The group of three caudal filaments (*3X*) is bound lightly together by adhesions of the pia and no oil flows between them (small filling defect). A larger group (*7X*) consists of seven filaments agglutinated to each other and the dura-arachnoid. This produces a large irregular filling defect similar to that in Figure *5D*.

found in complete block except for the element of degree. The lesion in our cases has been associated with direct or transmitted trauma, intrathecal hemorrhage, local non-suppurative arachnoiditis and the scarring resulting from same.

Illustrative myelograms are shown in Figures *2C*, *2D*, *5D* and *6C*.

6. *Altered Physical Characteristics of the Oil.* Pantopaque is an excellent contrast medium for myelography. One of its many advantages over lipiodol is its cohesiveness. When pantopaque fails to remain in a column or disperses into fine droplets, we have found it to be associated with alterations in the cerebrospinal fluid.

Abnormal behavior of the oil in myelography has been found in nearly all cases showing high cerebrospinal fluid protein. It was noted in 2 cases showing xanthochromia.

After withdrawal of the oil (Case II) we noted on gross inspection that the oil was opalescent due to fine droplet formation and apparent emulsification. In another case (X) the oil was slow in settling out to the bottom of the syringe.

We could not do extensive chemical determinations and have no accurate explanation of the phenomenon, but one may state that roentgen or gross observation of altered physical properties of the pantopaque in myelography is presumptive evidence of abnormal spinal fluid.

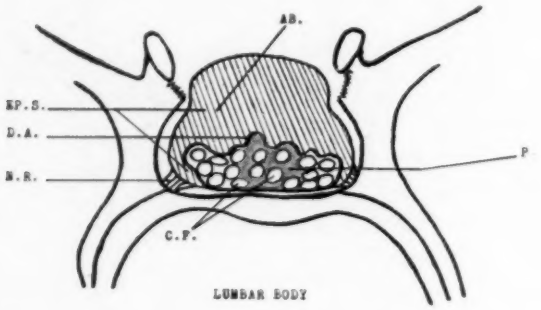

DIAGRAM 6. *Almost complete subarachnoid block produced by extradural pressure.* This is drawn from an epidural abscess (Case XII, Fig. 12, *A*, *B* and *C*). The dura is compressed, the caudal filaments are crowded together, and oil (*P*) flows only where there is space for it. There was a previous laminectomy. The abscess is shaded (*AB*).

7. *Complete Subarachnoid Block.* Complete subarachnoid block can be diagnosed by lumbar puncture along if the needle can be placed in the subarachnoid space below the lesion (see Technique).

Block can be diagnosed at any level by opaque myelography no matter where the needle is placed. We have introduced oil below, above and in 2 cases both below and above the block (Fig. 3, *C* and *D*).

Anatomically, subarachnoid block is obliteration of the subarachnoid space surrounding the cord or filaments of the cauda equina. It may be produced by (*a*) extrinsic pressure; (*b*) intrinsic pressure; (*c*) active inflammatory process; or (*d*) scarring as the result of very extensive destruction of nerve tissue.

The myelographic appearance is variable. The oil column may taper to a point before stopping or it may terminate in a ragged oblique or transverse manner.

In our series complete block to the oil column has been found in:

1. *Epidural Abscess* (Case IV): This is illustrated in Figure 4, *A* and *B*. The epidural abscess communicated with a paraspinous and perirenal abscess. The dura at operation appeared intact and was not opened. The patient made a partial recovery following drainage of the abscess. A similar abscess produced incomplete block in Case XII (see Fig. 12, *A*, *B*, and C and Diagram 6).

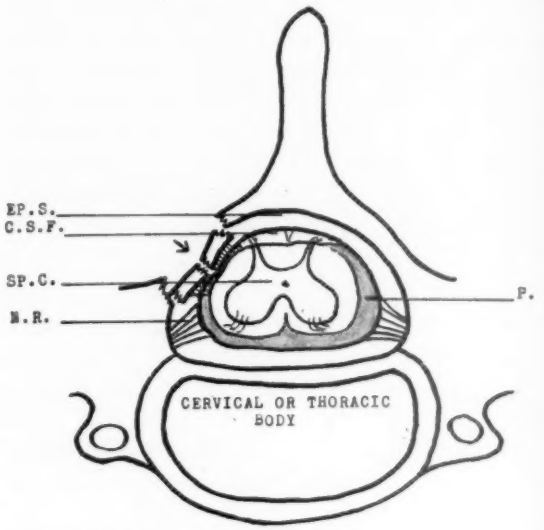

DIAGRAM 7. *Cervical and thoracic regions.* This diagram is included to emphasize the subarachnoid anatomy about the cord and its effect upon the opaque myelogram. Here the subarachnoid space is shallow and readily obliterated. Even slight indentation of a lamina may produce a large filling defect or block on one side. Note that only a thin layer of oil (*P*) surrounds the spinal cord and that in this position the dorsal surfaces of the cord are free of oil.

2. *Internal Pressure* (Case II): This is illustrated in Figure 2. This patient had a bullet lying in the neural canal like a cork in a bottle preventing the flow of cerebrospinal fluid and of the opaque oil. At operation the caudal filaments had to be combed

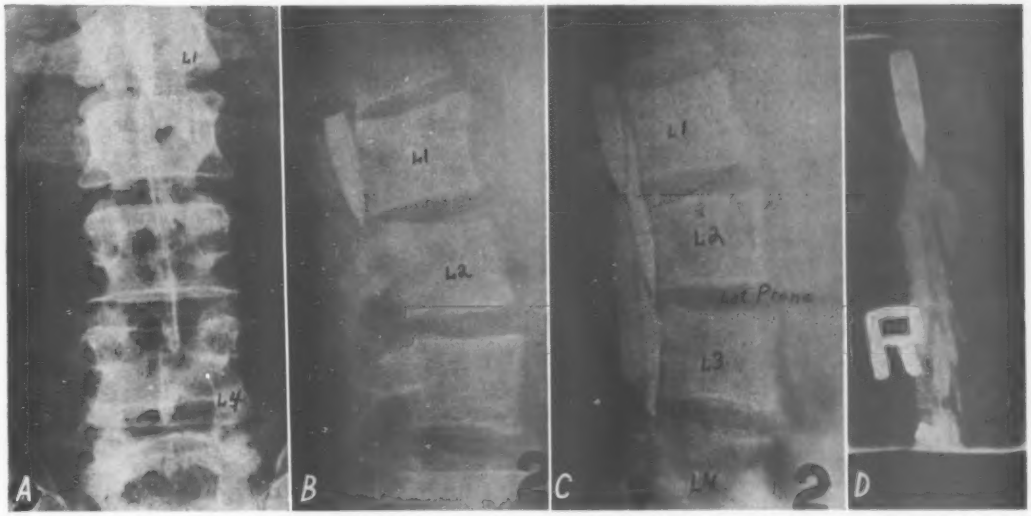

Fig. 2. Case II. Complete block of the internal variety. *A* and *B* show the rifle bullet lying within the neural canal. The only fractures to be seen are in the right lamina of L2 and the right transverse processes of L2, 3 and 4. *C*, lateral prone with head down 45 degrees. The oil fails to pass the bullet and several caudal filaments are adhered producing linear and branched filling defects. *D*, anteroposterior view with head down. The block results from two factors: (1) the mechanical plugging effect of the bullet, and (2) adhesive piaarachnoiditis of the caudal filaments. Note the strand-like negative shadows in the oil column. This oil was not in the epidural space as its appearance suggests. Note irregularity of left border, the side of symptoms.

apart before the bullet was recovered. The dural tear through which the bullet entered was found at L2. The bullet lodged at L1. The conus medullaris which was at T12 appeared normal. The patient made a complete recovery.

3. *Transection and Obliteration* of the cord or cauda (Cases III and VIII): An example of this is seen in Figure 3*A*. Here the missile tract is clearly seen to go through the neural canal from side to side. The oil block extends well above and below the site of damage to the cauda equina. Operation disclosed no recognizable thecal or nerve tissue in this region. There was universal replacement by scar tissue below L3. In such a case one cannot anticipate improvement.

A complete myelographic study is one which outlines the subarachnoid space above, below, and at the level of the lesion. Prone, supine and oblique views should enable the examiner to construct a three dimensional picture of the gross pathological lesion. This is, however, impossible in the presence of complete block.

The obliteration of the subarachnoid space usually extends over a larger area than is occupied by the actual lesion and prevents the oil from reaching and outlining the underlying pathological process. Thus one can usually diagnose only the existence and level of the block and cannot demonstrate the underlying lesion. An accurate estimate can be made concerning the extent of the subarachnoid obliteration by introducing oil below and above the suspected level and attempting to cause the columns to flow together (Fig. 3, *C* and *D*).

INDICATIONS FOR MYELOGRAPHY

We believe that, ideally, every patient exhibiting neurological signs following a wound involving or suspected of involving the neural canal should have a myelogram. This concept must of course be modified to conform to practical considerations; for instance, it is obviously impractical in the preoperative handling of freshly wounded patients in the forward areas. Here immediate surgical decompression of the cord is considered preferable to delay for any

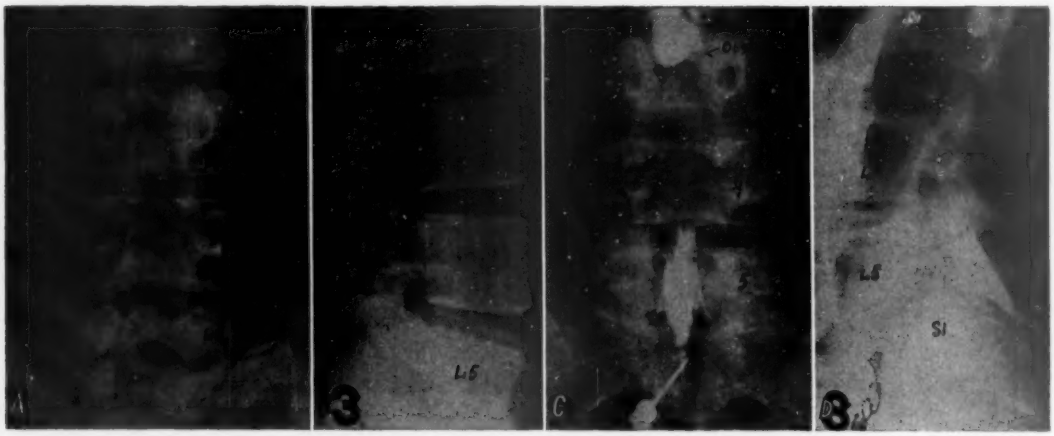

FIG. 3. Case III. Severe destruction of the cauda equina and complete subarachnoid block. *A* and *B* show the marked shatter and scatter effects of the shell fragment which passed directly through the neural canal from right to left at L4. *C*, oil has been injected above and below the subarachnoid block. Only 3 cc. of spinal fluid could be obtained from the lower needle. Although the cauda was destroyed only at L4 the subarachnoid space is sealed off as high as the upper margin of L3. At operation this was all dense cicatrix. *D*, lateral view showing oil above and below the block.

reason. If it were possible to do myelograms without delaying surgery, we should advise them in this group also.

FIG. 4. Case IV. Complete subarachnoid block due to epidural abxcess. *A* and *B*, patient prone in head down position. This large abscess was discovered twenty-eight days following previous laminectomy and removal of a shell fragment at L2. The oil reveals only the level of block and does not outline the abscess also present at L2.

Subacute Group. If there has already been a delay of two days to several weeks for any reason, however, we believe the further delay necessary to do a myelogram is justified. In this group there are certain very definite reasons for myelography:

1. One can differentiate between surgical and non-surgical lesions of the cord or cauda (Case X, Fig. 10).

2. Opaque foreign bodies and bone fragments can be localized with respect to the thecal canal (Cases VI and XI).

3. Any lesion can be accurately localized and marked for the neurosurgeon.

4. The cephalad or caudad extent of a lesion can best be determined by this means, thus indicating how many laminae to remove (Case XIII).

5. The ventral portion of the thecal space can be examined and one can advise the neurosurgeon as to the advisability of exploring anterior to the cord or dura.

Chronic Group. We believe that in this group exhibiting neurological abnormalities weeks or months after injury or operation *all* should have myelograms for the following reasons:

1. In those never operated upon one may demonstrate a clear cut operable lesion. In

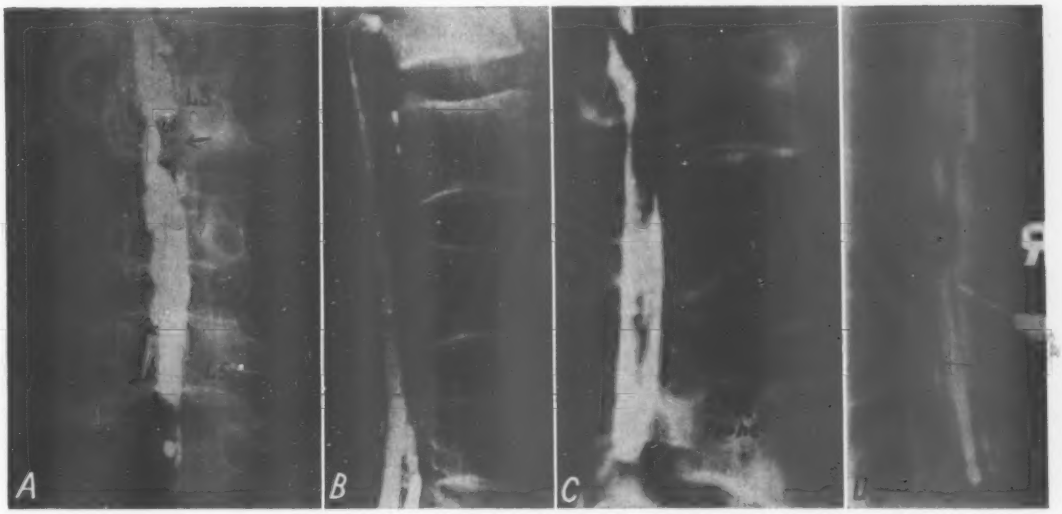

Fig. 5. Case v. Sharply marginated indentation and localized pia-arachnoiditis. *A*, the sharp indentation is at the level of the left pedicle fracture. The oil is in fine droplets. *B*, supine lateral view shows fine serrations of the dorsal margin of the oil column and two indentations at the level of L_3. *C*, prone lateral view exaggerates the large defect in the ventral margin of the oil column at L_3. *D*, prone oblique shows typical "feathery" filling defects of pia-arachnoiditis. In this case there was agglutination of the caudal filaments and a group of filaments were bound by adhesions to the dura-arachnoid at L_3.

our cases, operation has been surprisingly effective as late as three months after injury.

2. There are several reasons for doing myelograms on patients previously laminectomized but who have failed to recover: (*a*) Abscess may have developed since the first operation (Cases iv and xii). (*b*) Bone fragments, hematoma, or foreign bodies in the neural canal may have been overlooked.

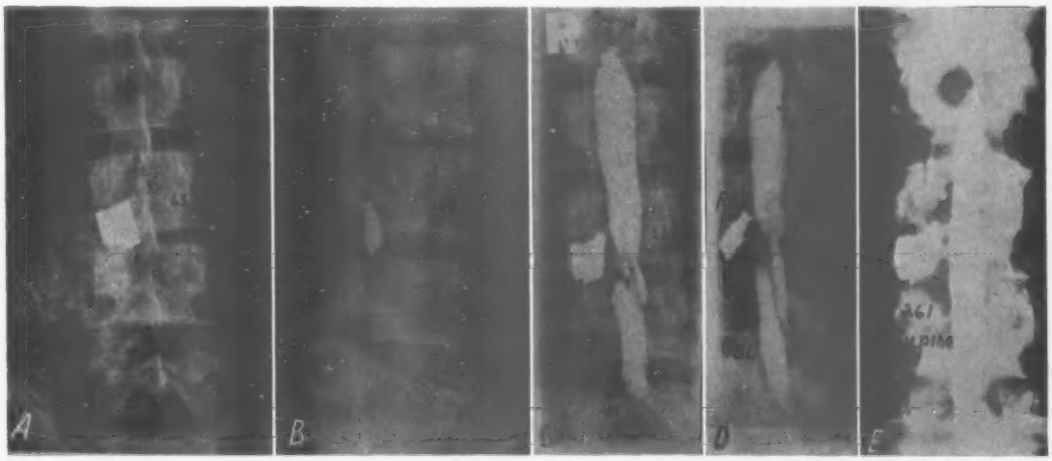

Fig. 6. Case vi. Shell fragment and clothing very near thecal canal. *A* and *B*, from these roentgenograms the cauda was expected to be severely injured. *C*, prone anteroposterior view. The oil column is constricted and "feathery" near the shell fragment but the latter is extra-arachnoid in position. *D*, prone oblique view shows the defect to be anterolateral. *E*, supine anteroposterior view shows no deformity of the column. In this position the oil is in contact only with the dorsal wall of the neural canal.

FIG. 7. Case VII. Narrowing of oil column in upper thoracic region. A rifle bullet passed through from front to back. *A*, prone anteroposterior view. Oil flows freely on the left but there is a clear cut indentation on the right at T_2 and T_3. *B*, prone oblique view demonstrates well the smooth contour of the compressed area. At operation the intact dura was impressed and depressed by bone fragments on the right.

(*c*) The operation may have been at the wrong level or an insufficient number of laminae may have been removed (Cases VIII and XI). (*d*) Certain operative records become lost or destroyed. In such cases myelography may reveal information concerning the previous operation and present status.

3. Before final disposition is made, myelography offers a possible means of studying the intradural anatomy, appraising the end-results of operations and establishing the prognosis (Case III).

CONTRAINDICATIONS TO MYELOGRAPHY

There are no contraindications in patients capable of undergoing operation. Unconscious patients are not suitable subjects. The needle should not be passed through bed sores. Patients with respiratory difficulties resulting from hemothorax, pulmonary edema or collapse of one or more lobes should of course have primary treatment directed to the thorax.

TECHNIQUE

The routine myelographic technique, ordinarily judged adequate for the diagnosis of herniated nucleus polposus and of cord tumor, must be extended to meet the problems presented by the wounded patient with a cord injury. Even though sensory loss precludes pain at spinal puncture, premedication is used. It is also found that preliminary explanation of the procedure to the patient makes him much less apprehensive.

Preliminary examination of plain roentgenograms of the spine usually directs attention to one level of injury and frequently gives valuable information as to the exact direction and level for spinal puncture.

Spinal tap is usually done with the patient on his side. When complete paralysis of the legs is encountered, it will be found that anteroposterior molded plaster splints extending above the knees makes the procedure easier for both the patient and operator. Whenever possible, the level of punctures should be two or more segments below the suspected site of abnormality or of previous laminectomy.

Fractional Queckenstedt Test. In all cases where spinal puncture is possible below the site of injury, a fractional Queckenstedt test should be done as a routine part of the procedure. The spinal fluid pressure is checked with the patient completely relaxed. The position of the needle tip in the subarachnoid canal must be confirmed by observing the rapid pressure rise and fall which results on coughing and straining.

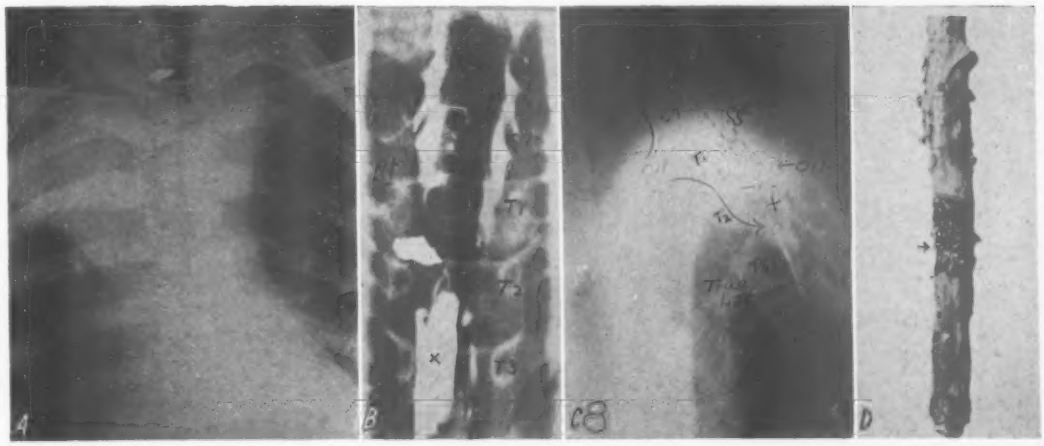

Fig. 8. Case VIII. Transection and necrosis of spinal cord. Fatal outcome. *A*, fracture of body of T1, poorly seen. Note pulmonary atelectasis. The foreign body is slightly posterior to the neural canal. *B*, prone anteroposterior view. Roentgenoscopically the oil passed cephalad to the foreign body only on the left. The subarachnoid space is obliterated on the right. The oil collection at *X* is outside of the subarachnoid space and presumably outside of the dura. It did not move with changes in position. *C*, prone lateral view (through the shoulders). The oil at *X* is dorsal to the main subarachnoid column. *D*, ventral dural surface of spinal cord removed at necropsy. The black area (at arrow) is the hemorrhagic necrotic granulating site of perforation by the missile. The cord was adherent to the dura-arachnoid and completely necrotic.

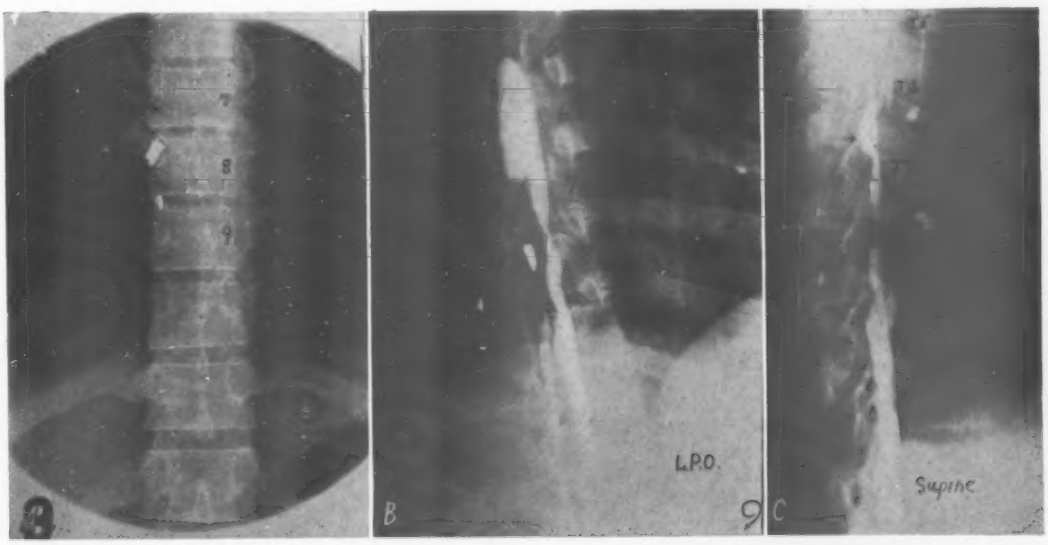

Fig. 9. Case IX. Compression by bone fragments. *A* shows fractures of the laminae of T7 and 8. The metal fragments are outside the neural canal. *B*, supine left posterior oblique view shows an oil "puddle" at T5 and 6 and narrowing of the column at T7 and 8. *C*, supine lateral view. The oil column is indented from the dorsal aspect at T7 and 8. Oil remains in the "puddle" (at arrow). The laminae of T5 and 6 were not removed in search for suspected dural tear, but the narrowing was produced by depressed small bone fragments.

Pressures of 20, 40 and 60 mm. of mercury are applied to the cervical veins by means of a blood pressure cuff wrapped about the neck. The pressure is maintained for twenty seconds, while manometer readings are taken and graphed at five second intervals. When normal hydrodynamics are present there will be a prompt pressure rise during the cervical compression, there being a greater rise with the greater compression. A prompt fall beginning at twenty-five seconds and returning to the initial level at sixty seconds is to be considered normal. It was found that a surprisingly gross myelographic defect sometimes failed to produce any abnormality in the curve of the fractional Queckenstedt test. In those cases where angulation of the oil column was found, a delayed return to the initial level was noted. When necessary, the fractional Queckenstedt test may be done with the patient prone. The curve is comparable with that taken in the decubitus position but the variations due to respiration are much more marked and the initial pressure covers a wider range.

Injection of the Opaque Medium. The patient is carefully rolled to the prone position before injection. Six cubic centimeters of pantopaque is used as the contrast medium. One-half cubic centimeter of oil is injected and checked roentgenoscopically before injection of the total amount. Three methods are used to check the entry of the pantopaque into the subarachnoid canal: (1) the patient is asked to cough; a splashing movement of the oil in the direction of the patient's head will be seen if the oil is in the subarachnoid space; (2) if the patient is able to use his abdominal muscles, he is asked to strain; the oil column will elongate and move cephalad; (3) tilting of the table will demonstrate free and prompt flow of the oil away from the needle tip. It should

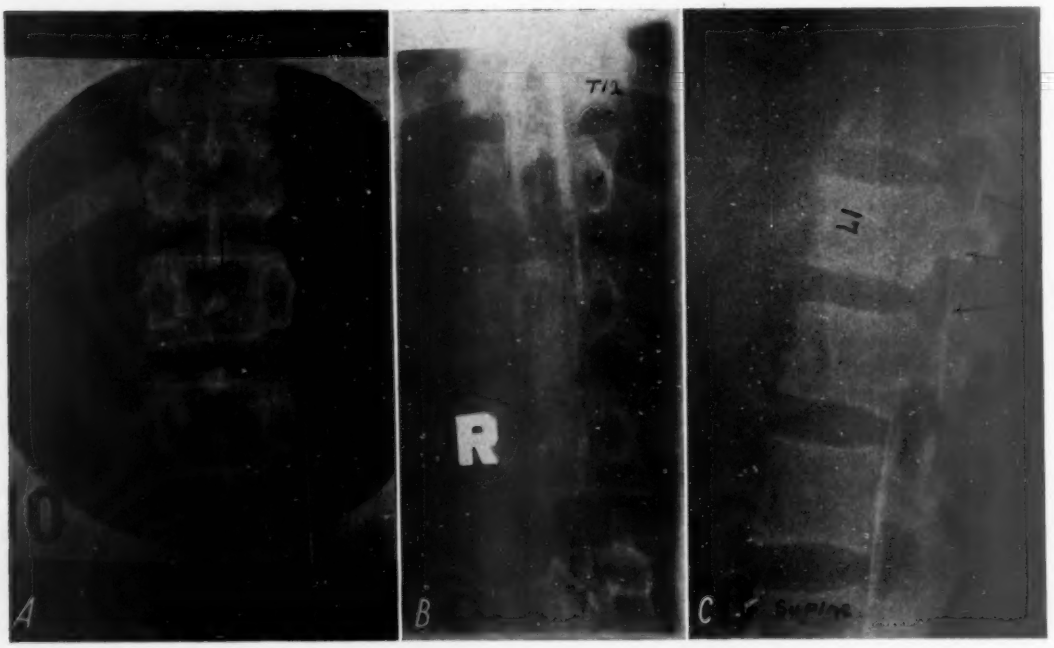

FIG. 10. Case x. Contusion of cord. *A*, fractures of spinous process and both laminae of L1. *B*, prone anteroposterior view. The oil is distributed thinly and in fine droplets. The fusiform filling defect at T12 and L1 remained in all positions. *C*, supine lateral view. There is slight anterior bulging of the dorsal wall of the neural canal (arrows). The oil is distributed as a thin coating over the cord. At operation the cord and conus medullaris were pale, edematous and pulseless, presumably due to contusion.

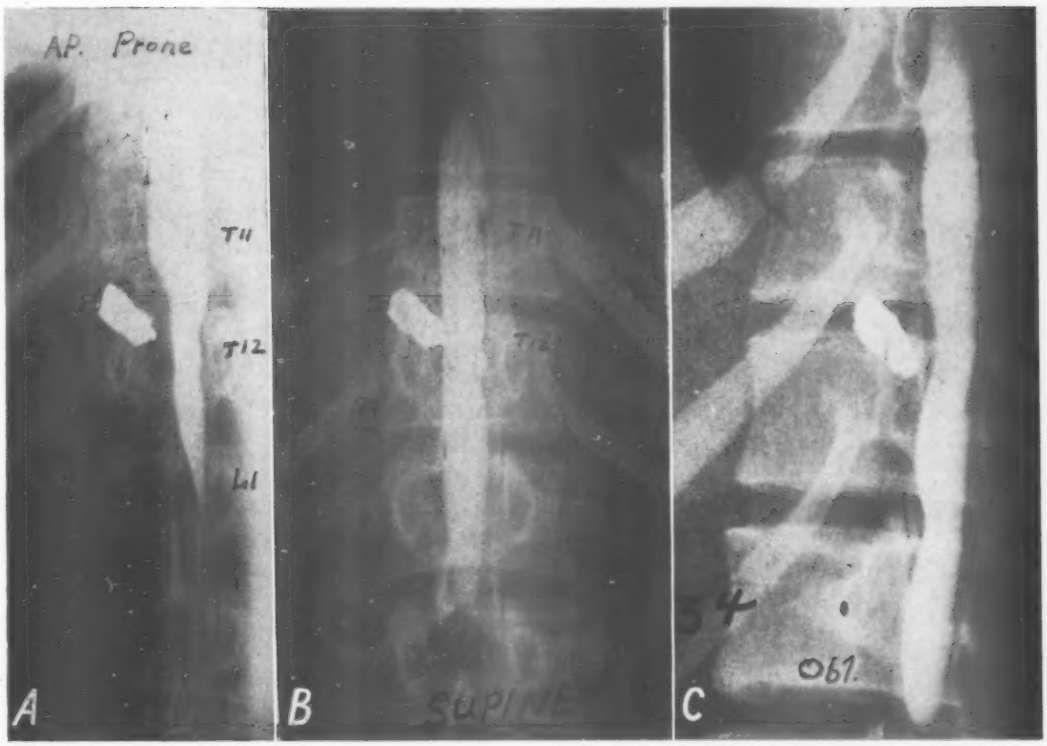

Fig. 11. Case xi. Extradural foreign body remaining after previous laminectomy. *A*, prone anteroposterior view. The oil column deviates to the left. The previous laminectomy was cephalad to the foreign body. *B*, supine anteroposterior view. The oil here outlines the dorsal wall of the neural canal which is normal. *C*, supine oblique view proves the extradural location of the metal fragment. At operation a bone chip was found indenting the dura from the ventrolateral aspect. No abscess about the metal fragment.

be noted that pantopaque in the epidural space will move away from the needle tip on tilting, but the movement is sluggish and dribbling. Only after these precautions, should the remainder of the oil be injected. Injection into the epidural space obscures the field, follows along the dural sleeves and cannot be completely removed.

Lumbar Lesions. It was found that removal of the needle during filming and roentgenoscopy expedited the procedure and facilitated complete examination. The oil column is brought to the level of injury, and preliminary roentgenoscopic examination in anteroposterior and both posterior oblique positions is carried out. Films are then made as indicated by roentgenoscopy. The following projections are most frequently used: (*a*) Anteroposterior myelograms in the prone position are best made with the roentgenoscopic tube, a rather narrow aperture, without grid and with the cassette in contact with the patient's back. It is not necessary to have a "spot film" device to obtain excellent myelograms. For an average male of 160 pounds we have the patient hold his breath and make an eight second exposure at 85 kv., 3 ma., as in roentgenoscopy. (Flipping the shutters open during the last 10 per cent of the exposure aids in the later identification of the vertebrae and does not materially fog the detail.) (*b*) Postero-oblique myelograms may also be made in this manner. (*c*) Lateral myelograms to demonstrate the ventral profile of the subarachnoid canal are made with the patient prone, and the central ray horizontal, using a wafer grid. It is impor-

tant to note that any myelogram taken in the prone position demonstrates only the ventral portion of the subarachnoid canal and unless the patient is examined in the supine and/or decubitus positions small lesions on the dorsal aspect will be missed. (see Diagrams 1 and 7). (*d*) Lateral and anteroposterior views with the patient supine are not always possible (as in mid-lumbar and cervical regions) but are valuable when obtainable. Other views are sometimes useful, such as (*e*) lateral views taken with the patient on his side, with the overhead tube and the moving grid. When using this position it is necessary to curve the patient's back with convexity downward in order to maintain the oil column at the desired level. (*f*) Anteroposterior views taken with the patient on either side, the central ray horizontal, and using a wafer grid are occasionally of value in studying the lateral margins of the subarachnoid space.

Thoracic Lesions. The mid and upper thoracic level may be examined in the supine and both decubitus positions. The same views are applicable here as in the lumbar area. Views taken in the region of T12 and L1 will frequently reveal a spindle-shaped filling defect about 10 by 1 cm. in the central part of the thecal canal. This defect is attributed to the lumbar enlargement of the cord (and the conus medullaris) which occupies more of the oil-bearing

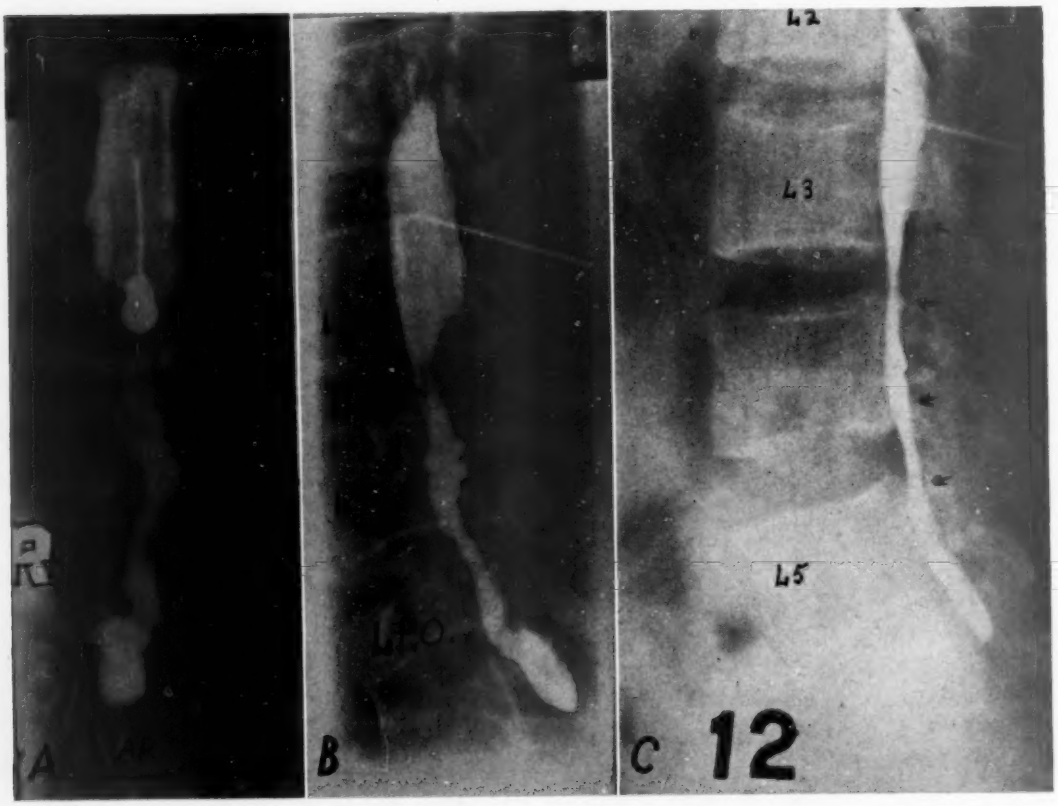

FIG. 12. Case XII. Epidural abscess about loose bone fragments nineteen days after previous laminectomy. *A*, prone anteroposterior view. The oil column is narrowed and irregular at L4 and L5. *B*, prone oblique view shows most of the compression and deformity to be on the dorsal surface. *C*, the oil column is compressed from its dorsal aspect (arrows). This is almost complete block. Note that the diagnostic needle is well above the lesion.

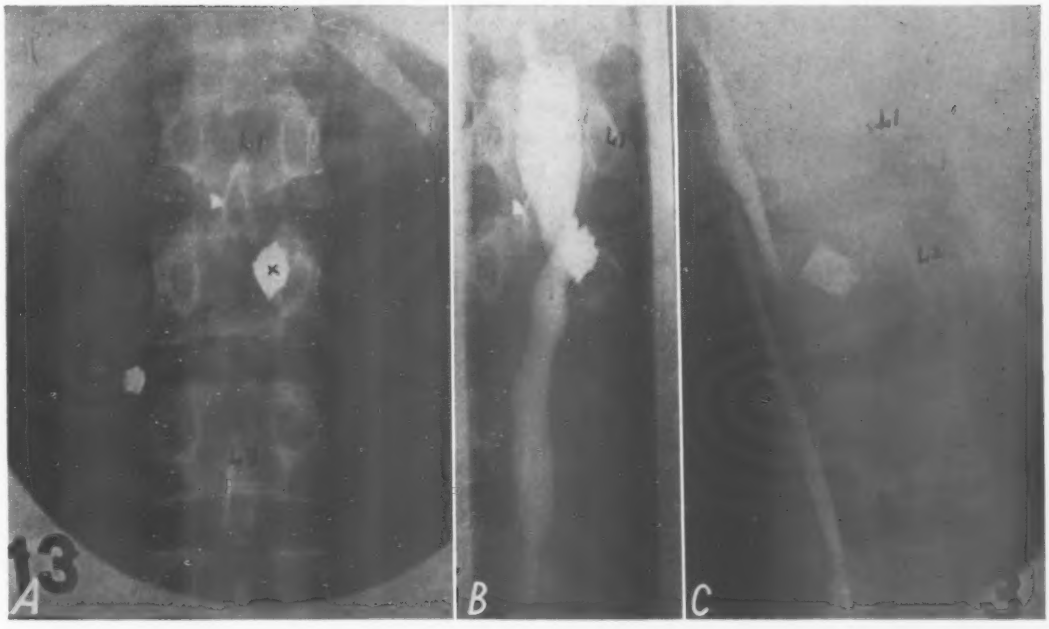

Fig. 13. Case XIII. Angulation and displacement of the oil column. *A*, arrows show path of the largest fragment. There are multiple shatter fractures of the right lamina and inferior articular process of L2. *B*, the oil column angulates to the left at the site of the metal fragment. The nerve root on the right was severed. *C*, prone lateral view. The metal fragment is buried in the body of L2. At L1 and L2 the oil is in apposition to the vertebral bodies but at L3 and L4 the oil is displaced backward several millimeters (arrows). Operation revealed an abscess about the foreign body and a large organizing hematoma ventral to the dura at L3 and L4 (arrows).

space than the cauda equina below or the narrower thoracic cord above (Fig. 10*B*). Lateral views taken in the thoracic region and in the region of the conus may reveal a division of the oil column into dorsal and ventral zones. This appearance is attributed to the displacement of oil by the spinal nerve roots and their associated arachnoid condensations. Neither of these appearances should be construed as abnormal.

Cervical Lesions. When the oil is injected in the lumbar region, the neck can be examined only in the prone and oblique positions. No position is available which will place the oil in contact with the dorsum of the cervical subarachnoid canal and still keep the oil out of the cranial cavity. (We have not used the cisterna route.) The oil column is brought into the cervical region under roentgenoscopic control. The patient lies prone, face forward, neck extended as far as possible with the chin elevated. The table is quickly tilted about 45 degrees head down. Just as the caudad end of the column passes the apex of the thoracic curve, the table is quickly returned to level. The patient's neck may then be relieved from the hyperextended position and the chin may be rotated with ease and safety. A doughnut shaped pillow is useful as a face rest.

Removal of the Opaque Medium. The procedure is completed by removal of the oil under roentgenoscopic control. It is possible to remove all the oil from the subarachnoid space. Non-removable oil may be considered to be in the subdural and epidural spaces. It is well to take a roentgenogram of such oil in order that it will not be confused with other more significant oil collections.

DISCUSSION

The great field of spinal cord injuries is a new one. Never before have so many patients been partially or completely incapacitated by trauma to the spine. The extreme emergencies encountered and the adverse conditions prevailing in the forward battle areas frequently prevent early operation. Many operations are incomplete or prematurely terminated due to circumstances beyond control. Certain patients are operated upon under circumstances of an emergency nature and operative notes reaching the rear echelon hospitals are incomplete, ambiguous or lost.

The neurosurgeon receiving such patients is confronted by very complicated and perplexing problems concerning late operation or re-operation, prognosis, dispensation and disposition.

We believe that opaque myelography carefully done gives the neurosurgeon more information concerning the location, size, configuration and actual nature of the lesion than can be obtained by any other means.

Our group of studied cases is conducive of some optimism. Frequently the neurological findings, plain roentgenograms and the locations of entry and exit wounds are misleading. We have found only a low percentage of cases with actual perforation of the dura and extensive cord destruction even though the missile passed through the neural canal. Much more frequently we find that the missile has passed through one or more of the bony walls of the neural canal, dislodging bone chips, giving rise to hemorrhage, abscess or arachnoiditis but sparing the thecal contents. In some cases the dura was torn and one or more roots cut but the presenting disability was actually due to adhesive pia-arachnoiditis, hemorrhagic granuloma, extradural foreign body, loose bone chips or abscess. All of these are surgically remediable and have a better prognosis than does true destruction of the cord or cauda equina.

Negative Value. In certain cases myelography indicates conservatism in treatment. A number of our patients (not included in this series) had wounds close to or definitely involving the spine. The neurological findings could have been attributed to intrathecal disease, and surgery was considered. In such patients, when the myelograms are normal or reveal only small defects in the margins of the oil column, it is considered inadvisable to operate. It is our conviction that lesions which do not produce considerable indentation, compression or other deformity of the oil column are not surgically remediable. Myelography consistently tends to magnify the lesions encountered, and for this reason a normal myelogram or one showing but minimal deformity is of considerable negative value.

CONCLUSIONS

1. Opaque myelography greatly facilitates the establishment of an anatomical diagnosis in spinal injuries.

2. We have described and illustrated certain myelographic abnormalities found following wounds of the neural canal. In the 13 operated cases we have correlated the roentgenographic with the surgical findings and have attempted to establish certain diagnostic roentgen criteria.

3. Even though the positions of the entry wound, missile tract and exit wound frequently suggest transection of the cord or cauda equina, this was found only twice in our series.

4. Extradural abscesses, hematomas, displaced bone fragments and pia-arachnoiditis frequently produce neurological findings simulating actual destruction of nerve tissue by the missile. These lesions are surgically remediable and carry a more favorable prognosis.

5. Operation as late as several months after injury is strikingly effective in selected cases.

6. A complete myelographic examination should reveal the intrathecal anatomy in three dimensions. This can be done in all

cases except in those having complete subarachnoid block and in lesions of the upper cervical region.

7. Myelography may reveal a residual remediable lesion even after presumably thorough surgical exploration.

8. Large lesions within the neural canal are not revealed by the fractional Queckenstedt test unless there is almost complete subarachnoid block.

9. Laboratory tests and gross inspection of the spinal fluid indicate abnormalities but do not permit accurate diagnosis except in complete subarachnoid block.

10. The use of myelography is recommended:

a. For preoperative diagnosis whenever practicable.
b. When operative records are inadequate or missing.
c. For evaluation of doubtful postoperative course.
d. For the diagnosis of late sequelae or complications of previous operations or penetrating wounds.
e. For final evaluation and disposition of the patients with persistent neurological findings at the completion of treatment.

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SUBDURAL PNEUMOGRAPHY

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SUBDURAL pneumography is the introduction of air into the subdural space so as to separate the brain from the skull and outline the contour of the cerebrum. This procedure demonstrates unknown attachments and abnormal adhesions between the cerebral cortex and the dura and skull. The visualization and localization of such attachments are especially important in jacksonian epilepsy and in post-traumatic cranial conditions. The demonstration of these attachments is valuable to the surgeon since definite localizing clinical signs cannot always be obtained. As is known, the resection of the scar tissue in these cases is followed by relief of the symptoms and cessation of the epileptic attack. The demonstration of other conditions by this procedure will be discussed in this paper. The method of subdural air insufflation was developed by Ney[3,4,5] in 1932.

The surgical technique for this examination is to make a small burr opening in the occipital region of the skull. A lumbar puncture is made at the same time with the patient in a sitting position. Between 30 and 60 cc. of fluid is withdrawn reducing the spinal fluid pressure to about 6 mm. of mercury. The dura is then picked up with a dural hook and a small nick is made in it. An audible hiss is heard as the air enters the subdural space, and the rate of flow of the cerebrospinal fluid increases. The spinal fluid pressure rises to its original level; 15 to 30 cc. more fluid is withdrawn. The dura is closed with a muscle graft and the patient is transferred to the roentgenographic room lying on the operated side. This is to facilitate the dissemination of air to the other side of the brain.

This procedure is less distressing to the patient than encephalography, but patients do, however, often complain of headache and nausea. To obviate this, 9–12 gr. of phenobarbital is given in divided doses, beginning four hours before the operation, the last dose being one hour before it. During the roentgen examination sudden movements of the head may cause considerable distress. Adjustments of the head to the various positions therefore should be slowly and carefully made. As a rule, the second day the patient is very comfortable except that headache is still apt to be induced when the position of the head is changed.

Interestingly enough, the disturbance attending subdural air insufflation very closely resembles the headache, nausea and vomiting attending migraine, and patients who have had migraine state that it is just like one of their old sick headaches, except that it is a little more severe. This suggests a possible relationship between migraine and the symptoms resulting from this procedure.

The technique used in taking these roentgenograms, I believe has definite advantages over the methods used for routine air studies of the head. The accompanying illustrations show fine definition and excellent contrast without a slight blurring of lines due to distortion resulting from the Bucky grid and without the marked enlargement of relative size of the structures. These roentgenograms are taken without the Bucky grid at a 6 foot tube-film distance. This distance gives a true size of the outline of the brain and the skull. The elimination of the Bucky grid gives a more finely detailed roentgenogram than can be obtained with the Bucky grid because of distortion and also gives better contrast between air and bone. A small cone is used, 18 inches long by 4 inches in diameter at its wide end. Centering is accomplished by darkening the room and using the light of the filament which just covers an 8 by 10 inch film. The use of a fine focus rotating anode tube at 100 milliamperes gives the optimum exposure. Stereoscopic views may

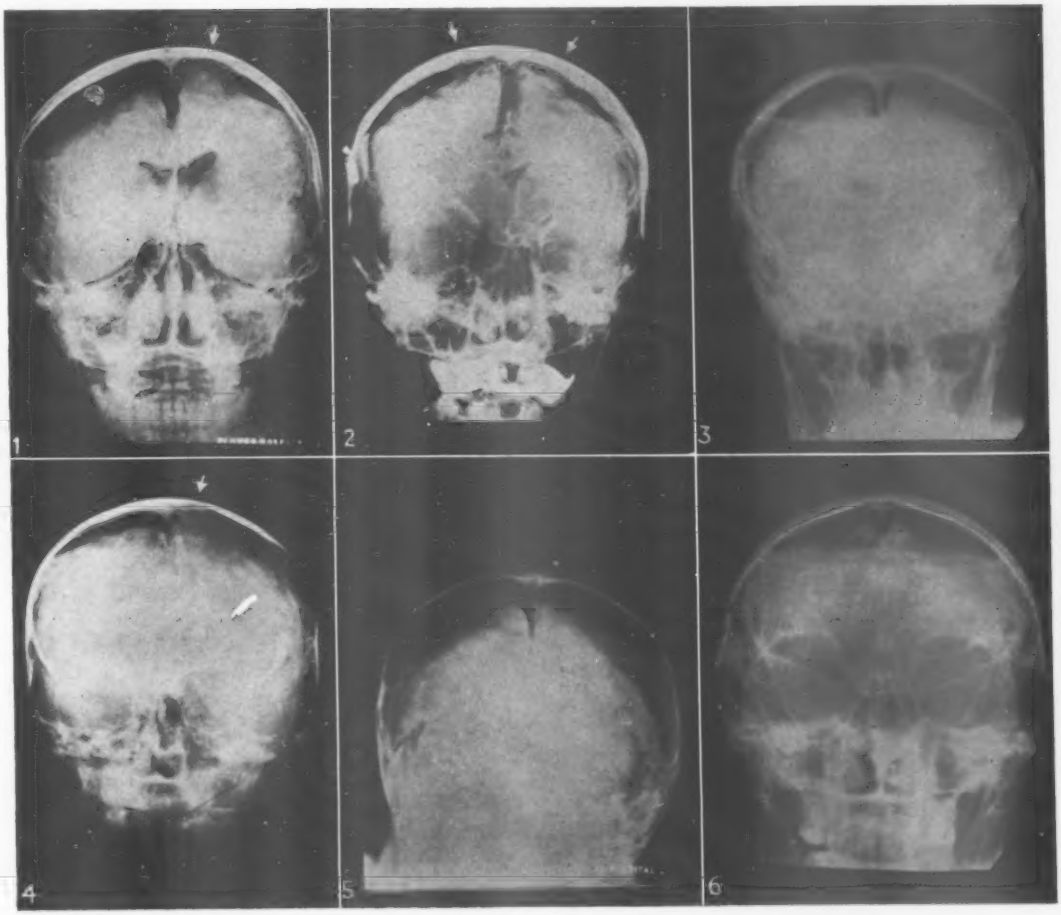

FIG. 1. *1* and *5*, an advanced case of epilepsy. These films show diminished corticodural attachments. In this case insufflation of air in the subdural space found its way rapidly into the ventricles suggesting a communication between the subdural space and the cerebrospinal fluid circulatory system. *2* shows fixation of the cortex lateral to the sagittal sinus. *3* shows extensive corticodural fixation with a definite fluid level. *4* shows a young child with epilepsy with extensive corticodural fixation on the left side with pacchionian granulation nearly penetrating the skull. *6* shows normal attachments.

be made in this way, but are not usually necessary if an adequate number of positions are taken. Five anteroposterior roentgenograms are taken (*a*) with the chin down near the chest (Fig. 1, *5*); this shows the posterior parietal region; (*b*) with the head straight erect (Fig. 1, *1* and *2*); this shows the region of the coronal sutures; (*c*) with the head thrown back to show the frontal region (Fig. 1, *6*); (*d*) tilting the head to the left and to the right showing relative displacement. Three lateral views are taken: first with the chin down; second, straight erect (Fig. 2, *5*) and third, with the head extended backward. Since the air absorbs slowly, a second series is taken twenty-four hours later. Any unsatisfactory roentgenograms are repeated and any of the other positions are taken which may be indicated by a study of the first set of roentgenograms.

Not more than 80 kv. is used for the anteroposterior views with 75 ma-sec. The lateral views are taken with 65 kv. and 100 ma-sec. The attempt is made to slightly underexpose and overdevelop the films. The roentgenograms are developed quite dark to bring out the greatest contrast possible between air and brain tissue.

ANATOMICAL CONSIDERATIONS

The subdural space is a potential space rather than a real one. It lies between the dura mater and the arachnoid mater and normally contains only a film of fluid, just sufficient to moisten the opposing surfaces of the two membranes. There is no connection in any way between the subdural and the subarachnoid spaces. The dura and the arachnoid, therefore, are in contact with each other and adhere by virtue of the small amount of viscid fluid between them, more or less as two pieces of thin rubber stick together if there is a film of oil between them. If these pieces of rubber were sealed along their edges, no air could enter and it would be practically impossible to separate the two pieces.

The arachnoid mater is a very thin membrane which envelops the brain and the cord. It does not dip into the sulci of the brain, in which respect it differs from the pia mater, but it is carried into the longitudinal fissure. It sends numerous strands or filaments to the pia mater connecting the arachnoid and pia in an intimate manner and forming a delicate sponge-like interlacement between them. This space between the arachnoid and the pia mater contains the cerebrospinal fluid. This fluid flows from one part of the brain to another along the sulci of the brain which serve as communicating passages for the free flow of the fluid.

There are bulbous protrusions of the arachnoid into the dura on each side of the superior sagittal sinus. These are the arachnoid granulations. They appear to belong to the dura but in reality they are excrescences of the arachnoid through the dura with a narrow pedicle and they contain cerebrospinal fluid. The distal end of the protrusion passes between interstices of the dura into contact with the endothelial lining of the sagittal sinus, with which it is fused. In this situation the subdural space is obliterated and the single membrane, resulting from the fusion, alone separates the blood from the cerebrospinal fluid. There are a number of large spaces on each side of the sinus into which most of the arachnoid granulations insinuate themselves, a few being invaginated directly into the sinus. These granulations serve as a channel for the passage of excess cerebrospinal fluid into the sagittal sinus. These larger granulations are called pacchionian granulations. They vary in size and enlarge with age. Investigators have found that these pacchionian granulations are not present normally at birth and are rarely present in young children. Also they are not found in the Anthropoidea. Weed[2] concludes that these granulations are overgrown arachnoidal villi. Cushing[6] says "Though the arachnoidal villi are clustered in special numbers in certain places, particularly along the sinuses, where they occur with or without association with the cortico-dural anastomotic veins, they are also found scattered elsewhere over the brain, and are doubtless capable of being newly formed where adhesions occur or where there is opportunity for the arachnoid to project into the dural crevices. It is into these villi that the minute cortical herniations take place . . . and those which occur in the lateral lacunae of the sagittal sinus, commonly spoken of as Pacchionian granulations, are the largest and most often commented upon."

The cerebrospinal fluid is formed in the lateral ventricles. It escapes through the apertures in the fourth ventricle into the subarachnoid space. Some of the fluid passes down in the spinal subarachnoid space, but the major part rises and finds its way slowly over the surface of the hemispheres to be absorbed through the arachnoid villi and granulations into the venous system.

SUBDURAL FLUID

Reference was made in a previous article[2] to the fact that in encephalographic studies, air is occasionally seen in the subdural space, sometimes immediately after the air was introduced and sometimes twenty-four hours later. Occasionally also air may pass into the subdural space at one examination and fail to appear in it at a subse-

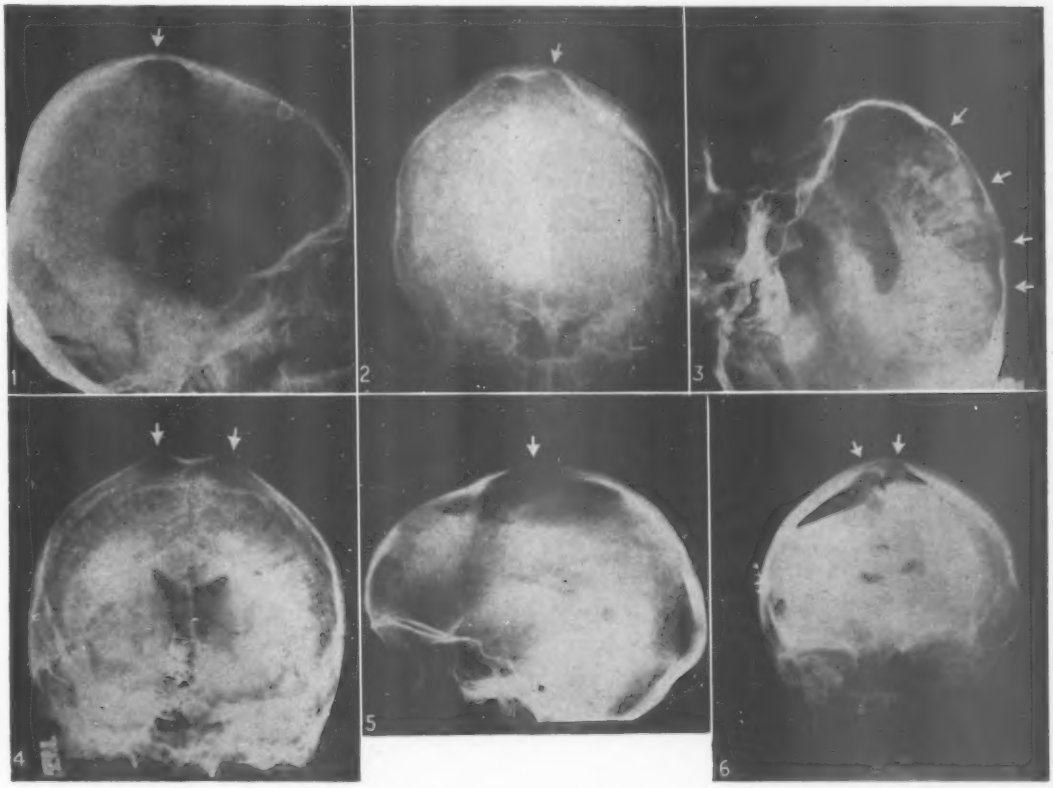

Fig. 2. *1*, an encephalogram showing pacchionian erosion of the skull. *2*, a plain roentgenogram showing pacchionian erosion. *3* and *4*, encephalograms showing extensive thinning of the skull. *5* and *6*, subdural air insufflation films with fluid level shown in the lateral view, and escape of air into the ventricles.

quent encephalographic examination. As previously mentioned, there is no connection, under normal conditions, between the subdural space and the subarachnoid. Even under extreme pressure fluid dye cannot be forced from the subarachnoid into the subdural space. However, when Weed[6] injected finely granular masses in the subarachnoid space under pressure he found that a large number of granules penetrated into the subdural space. From this he concluded that the granular masses cut an opening into the subdural space, while the fluid could not.

These facts would suggest that the pathway of the air in reaching the subdural space, as shown in some of these encephalographic studies previously mentioned, might be through an arachnoidal tear or defect. Ney[4,5] has definitely demonstrated at operation such a tear or fistula. He states that when the dura is carefully reflected toward the sagittal sinus, an escape of cerebrospinal fluid is observed through such a fistula, and if air is locally injected into the subarachnoid space, it may be directed toward the fistula, through which it will escape as bubbles.

When an encephalogram shows that air has escaped into the subdural space there may also be seen, at times, a definite in crease in subdural fluid (see Fig. 1, *3* and *6*, and Fig. 3, *1* and *3*, which show a small amount of lipiodol floating on top of the fluid to accentuate the presence of the fluid level in the subdural space). This would suggest that cerebrospinal fluid passes into the subdural space by the same route that the air took in reaching there, i.e. through an arachnoidal fistula.

CORTICODURAL ATTACHMENTS

It is interesting to note in these encephalograms showing subdural air and increased fluid that the cortex of the brain falls away from the vault of the skull, leaving attachments at the top in the region of the sagittal sinus. The normal appearance of such attachments is illustrated in Figure 1, *6*.

By subdural air insufflation these attachments can always be demonstrated and studied. There is a wide variation in the size and extent of these attachments. Figure 1, *1*, *2*, *3* and *4*, and Figure 2, *6* show marked enlargement of these attachments. Figure 1, *1* and *2*, shows attachments lateral to those along the sagittal sinus. These broadened attachments contain enlarged pacchionian granulations.

PACCHIONIAN GRANULATIONS

Various sized depressions are found in the inner table of the skull where these large arachnoidal granulations are attached. These depressions are erosions of the inner table of the skull, in which are fixed the enlarged pacchionian granulations. In certain instances these granulations become directly attached to the cerebral cortex, and firmly anchor the cortex to the skull. At times the erosion of the inner table is so marked that the skull is thinned to a point

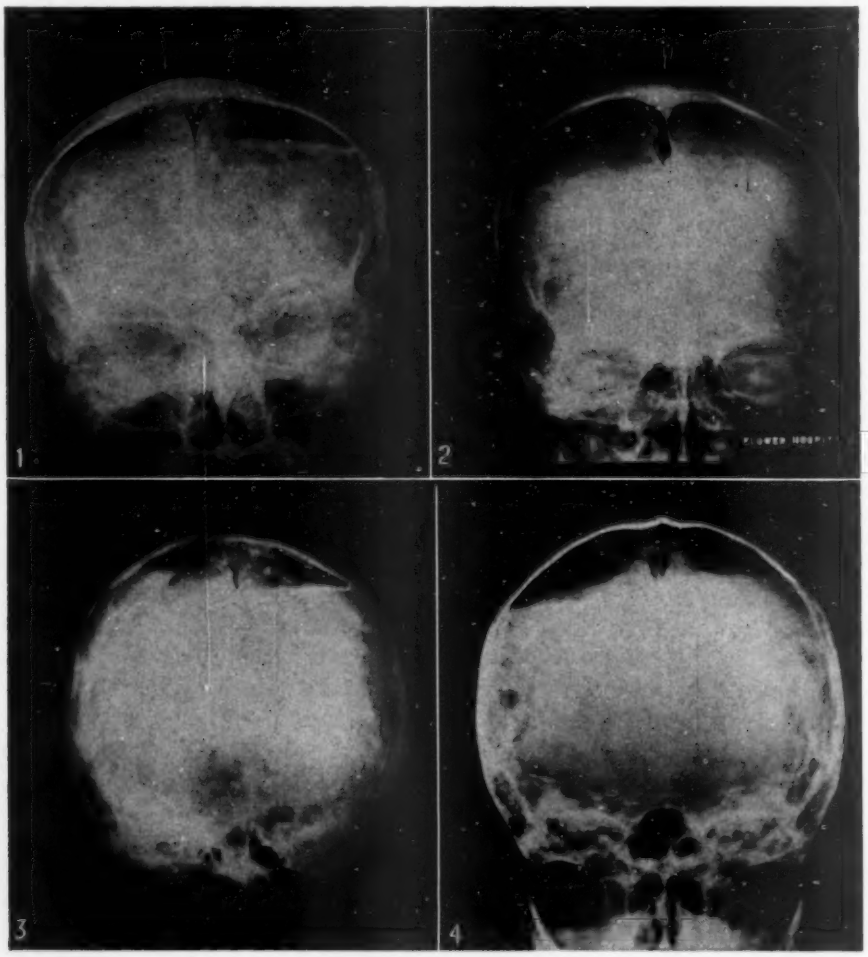

FIG. 3. A series of subdural air insufflations with ascending lipiodol floating upon the fluid in *1* and *3*. In *2* and *4* a definite fluid level may be observed. Film *2* is a seven-year old child with epilepsy. Note the difference in the corticodural attachments.

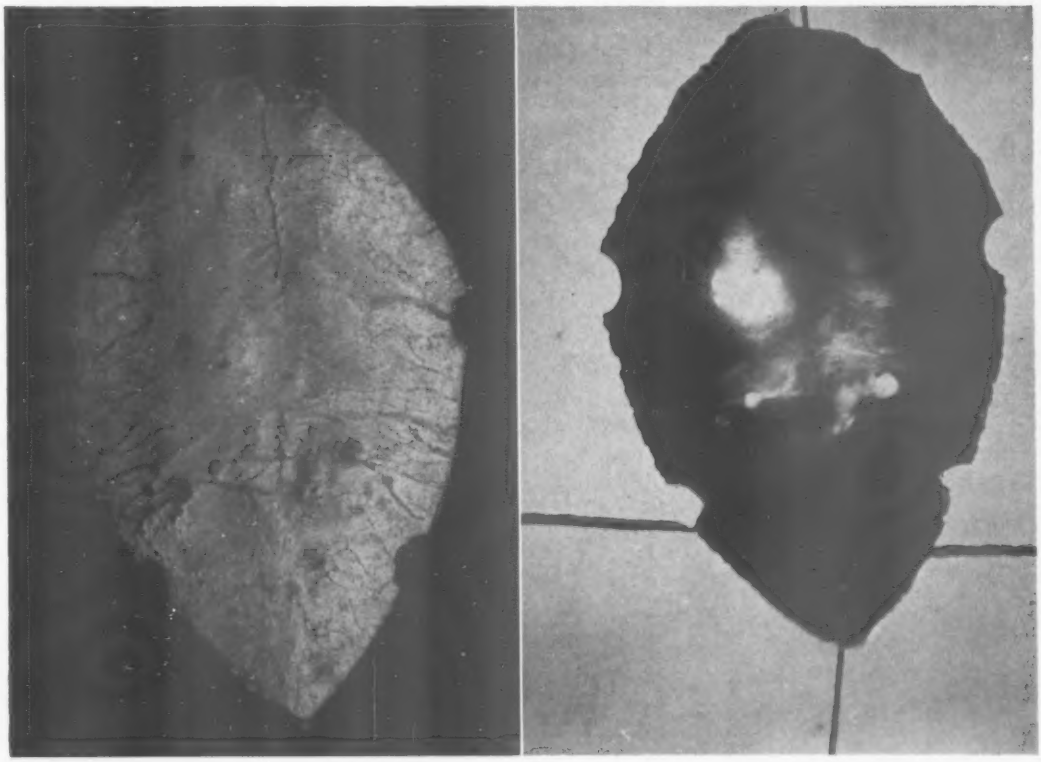

Fig. 4. Resected calvarium; two views, one with light behind it to show its thinness.

where it is translucent (Fig. 4). These films show a resected portion of the calvarium, one having a light behind it shining through illustrating the thinness and transparency of the bone. At operation these eroded areas are found to contain pacchionian granulations which are partly buried in the bone as though the tissue were digging into it.

SUPPORT OF THE BRAIN

In these roentgenograms taken after subdural air insufflation the cortex falls away from the vault of the skull leaving a space variable in depth. In Figure 1, *1*, there is more air on the right side than on the left. The left side of the cortex appears to be held by an additional attachment pointed out by the arrow. The right ventricle is proportionately lower in position than the left, due to this support. A similar appearance is observed in Figure 2, *6*. This displacement of the ventricle is never observed in encephalograms without subdural air. The oblique views also show postural displacement. The displacement is not due to pressure, because the air is at atmospheric pressure. Unless the ventricles are displaced by some increased pressure they do not change in position in the skull in routine encephalograms, no matter in what position the head is held. Therefore, it appears that the subdural space maintains a negative pressure which keeps the brain cushioned within the skull. In subdural air insufflation the air sucks into the subdural space, when the dura is opened, and is not forced into it. This releases a negative pressure in the subdural space and the cortex falls away by gravity from the top of the skull. This gravitational effect throws tension upon the attached portions of the cortex, and demonstrates them. It actually produces a stretching of the attachments. A similar condition is present when increased subdural fluid is found instead of air. The subarachnoid membrane appears

to be no longer intact permitting fluid to enter the subdural space through a fistula.

Subdural pneumography has demonstrated that the amount of fluid in the subdural space varies from time to time. Under different conditions of the patient it may increase or be absorbed. The air and fluid in the subdural space, following insufflation, diminish rapidly when the patient strains severely due to vomiting. In the recurrent sick headache attacks, which are practically always accompanied by continuous vomiting, relief of the headache follows the vomiting.

In conclusion, therefore, we may say that this procedure of subdural pneumography opens a new field of study revealing variations in the support of the brain within the skull, the presence of variations of the corticodural attachments, and the presence of a variable amount of fluid in the subdural space.

SUMMARY

1. Introduction of air into the subdural space as a diagnostic procedure is described.

2. The anatomical features which this procedure reveals are discussed and illustrated.

3. The explanation of the presence of increased subdural fluid is suggested.

4. The attachments of the brain are described and abnormal fixations illustrated.

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REFERENCES

1. CUSHING, H. Studies on cerebro-spinal fluid. *J. Med. Research*, 1914, *31*, 1–19.
2. HOWARD, C. Observations on encephalography. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 301–310.
3. NEY, K. W. Epilepsy—mechanical theory and results of treatment. *J. Am. Inst. Homeop.*, 1933, *26*, 241–248.
4. NEY, K. W. Pathologic factors found in surgical investigation of epilepsy. *Am. J. Surg.*, 1940, *47*, 573–585.
5. NEY, K. W. Traumatic epilepsy; pathologic factors. *J. Med. Soc. New Jersey*, 1943, *40*, 270–275.
6. WEED, L. H. Studies on cerebro-spinal fluid. *J. Med. Research*, 1914, *31*, 51–91.

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OSTEOCHONDRITIS DISSECANS OF THE SUPRATROCHLEAR SEPTUM OF THE HUMERUS

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THE presentation of this paper was stimulated by the report of Crysler and Morton[1,2] presented at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America in Chicago, Illinois, September, 1944. On that occasion they presented for the first time 6 cases of osteochondritis dissecans of the supratrochlear septum of the humerus, 5 of which were confirmed pathologically, which they had personally observed. A review of the literature by them revealed that 6 similar cases had been previously reported, none of which, however, had been correctly designated as osteochondritis dissecans.

Normally, just above the lower end of the anterior aspect of the humerus there is a shallow depression below which is the trochlea. This depression is the coronoid fossa, which receives the coronoid process of the ulna during flexion of the forearm. As the trochlea continues around posteriorly, it terminates in a broad, deep, triangular depression, the olecranon fossa, in which the summit of the olecranon process of the ulna is received in extension of the forearm. These two fossae are separated from one another by a thin, transparent lamina of bone, the supratrochlear septum. Sometimes this is perforated by a foramen.

The abnormal roentgenographic findings in osteochondritis of the supratrochlear septum, as described by Crysler and Morton, consisted of a separate ossicle of bone arising from the septum in various degrees of sequestration. An additional finding was the presence of a supratrochlear foramen or thin septum in the opposite humerus.

The clinical findings varied from recurrent attacks of pain and limitation of movement in the elbow joint to locking of the elbow. Tenderness over the olecranon process or in the region of the biceps tendon was common. Surgical interference, with removal of the bony ossicles, resulted in complete relief of signs and symptoms.

Shortly after this report, we had the opportunity of seeing 5 cases which were very similar to those reported. Undoubtedly other instances were seen by us and others in the past and probably reported as fractures of the olecranon tip or dismissed as anatomical variations. We are reporting these cases of osteochondritis dissecans of the supratrochlear septum because we feel the entity is not uncommon and may be easily overlooked.

REPORT OF CASES

CASE 1. While entering the top hatch of an airplane two weeks prior to admission, this patient slipped and fell, catching his weight on his flexed elbows. The right elbow received most of the impact. Three days later he reported to sick call because of soreness of his right elbow and inability to completely extend his forearm.

Past History. The patient was a professional golfer prior to entering the service. There was no history of any previous injury to his right elbow.

Complaints on Admission. Inability to completely extend right elbow, pain on attempted passive extension of elbow, and occasional "catching" and "twinge" of pain in right elbow on sudden exertion, such as picking up baggage or swinging a golf club.

Physical examination revealed a swollen right elbow joint with 15 degree limitation of extension. There was a complete range of flexion, supination and pronation. No definite areas of tenderness were elicited.

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FIG. 1. Case 1.

Roentgen Findings. Left elbow: The bones of the left elbow joint are normal. The supratrochlear septum is intact. Right elbow (Fig. 1): In the region of the supratrochlear septum, there are two irregular fragments of bone measuring 6 by 9 mm. and 6 by 11 mm. in diameter respectively. On the lateral view, a third bony fragment is visualized just above and anterior to the olecranon process. The former two fragments probably represent an osteochondritic process of the supratrochlear septum. The third fragment may represent an old injury of the olecranon process.

Right elbow (Fig. 2) after operation: The two bone fragments previously described in the region of the supratrochlear septum are no longer present. The septum itself is thinned as compared to the one on the left.

Operative Findings. The supratrochlear fossa was exposed through a posterolateral skin incision and splitting of the lower fibers of the triceps muscle. The capsule was opened with a longitudinal incision. A free, round, loose, cartilaginous body about the size of a small pea was removed from the supratrochlear fossa (Fig. 3). There was no perforation of the intercondylar septum. There was a small fragment of bone attached by fibrous tissue to the tip of the olecranon process and attached to this fragment was another small cartilaginous body (Fig. 4). The bone fragment with the attached cartilaginous body was removed. The elbow could now be extended to within 5 degrees of normal. The wound was closed and the elbow partially immobilized with cotton padding and ace bandage dressing with Velpeau sling. Slight active motion was begun on the second postoperative day and physiotherapy instituted ten days following the operation.

The soldier was returned to full duty five weeks following operation. Final examination revealed 5 degrees limitation of extension of the right elbow with complete range of flexion, supination and pronation. There was no complaint of pain in the elbow.

Pathological Report (Major Louis Parmacek). The gross specimens consisted of three firm, white, smooth bodies. Two of the pieces, measuring approximately 1 by 1 by 0.2 cm. in diam-

FIG. 2. Case 1.

eter, are attached to each other, apparently imbedded in a tough, glistening cartilaginous substance. They are held together by thin, fibrous strands. The third specimen is completely free of connective tissue covering and shows an exposed surface of bone on one side. No histologic preparations of these specimens were made. The histopathologic changes as seen in other specimens consist of demineralization, poor staining, and shrinkage or disappearance of the cells.

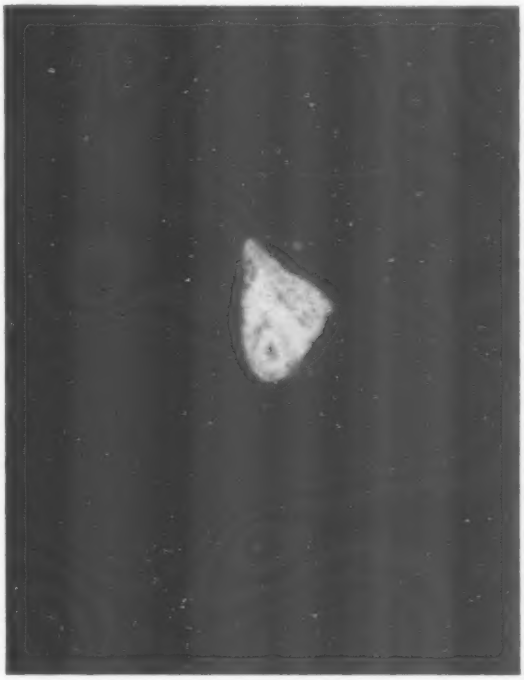

Fig. 3. Case I.

Lacunae may show on the fractured surface, which becomes covered by connective tissue proceeding from the marrow spaces. This may be transformed to fibrous cartilage or even osteoid tissue. Occasional foreign body giant cells are seen.

Osteochondritis dissecans is essentially an aseptic necrosis of an osteocartilaginous sequestrum completely or incompletely separated from the underlying bone. The basis for this necrosis is probably vascular and of traumatic origin. The necrotic changes are more strikingly evidenced in the bony portion of the sequestrum, the cartilaginous portion showing lesser changes and actually on occasion continuing growth with the formation of knobby prominences.

Fig. 4. Case I.

Fig. 5. Case II.

FIG. 6. Case III.

CASE II. This soldier entered the hospital complaining of a tingling sensation in the fifth right finger and some weakness of the right hand.

FIG. 7. Case IV.

Physical examination was essentially normal except for 5 degree limitation of extension of the right forearm.

Roentgen Findings. Left elbow: The bones of the left elbow are normal. Right elbow (Fig. 5): There is an ovoid bone fragment measuring 6 by 8 mm. in diameter present in the region of the supratrochlear septum. This probably represents an osteochondritic process of the septum.

FIG. 8. Case V.

CASE III. The patient fell on the right elbow six years ago. This was followed by swelling and pain with some imitation of motion.

Physical examination shows 30 degrees limitation of extension. Pronation and supination are slightly limited. There is no swelling. Tenderness is present over the olecranon process

Roentgen Findings (Fig. 6). There is a single, large bony ossicle present in the region of the supratrochlear septum of the right humerus.

CASE IV. This patient fell approximately seven years ago striking the left elbow. Complains of weakness and loss of strength in that arm.

Physical examination shows 20 degrees limitation of extension. Pronation and supination

are very slightly limited. There is no swelling or tenderness.

Roentgen Findings (Fig. 7). There is an irregular, ovoid, bony ossicle present in the region of the supratrochlear foramen of the left humerus.

CASE V. This patient injured his elbow while playing football six years ago. He is asymptomatic most of the time, but occasionally the elbow locks so that he cannot extend it fully.

Physical examination at this time is entirely normal.

Roentgen Findings (Fig. 8). There is a single large, ovoid, bony ossicle present in the region of the supratrochlear septum of the right humerus.

SUMMARY

Five cases, similar in roentgen appearance to those recently described as osteochondritis dissecans of the supratrochlear septum, are reported.

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REFERENCES

1. CRYSLER, W. E., and MORTON H. S. Osteochondritis dissecans of the supratrochlear septum of the humerus. AM. J. ROENTGENOL. & RAD. THERAPY, 1945, *54*, 41–46.
2. MORTON, H. S., and CRYSLER, W. E. Osteochondritis dissecans of the supratrochlear septum. *J. Bone & Joint Surg.*, 1945, *27*, 12–24.

THE INFLUENCE OF POSITION ON THE MEASUREMENT OF THE PROJECTED BONE ANGLE

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IN DESCRIBING normal or abnormal angulations of bones or fractures emphasis has been placed on reporting the number of degrees actually measured on the roentgenogram.[2,5] Obviously the reporting examiner should understand how readily change in the position of the examined part may alter the measurement of the projected angle. In searching the literature, however, I was unable to find any discussions concerning the measurement of the projected bone angle except the brief notes of Glasscheib,[3] and Schinz,[4] who stress particularly the importance of proper positioning in the making of roentgenograms for measurement of the angle of the femoral neck. In view of this lack of available information, and in view of numerous questions concerning the measurement and projection of bone angles on the roentgenogram, the following observations are presented for the purpose of demonstrating the underlying principles of this neglected but nevertheless important subject.

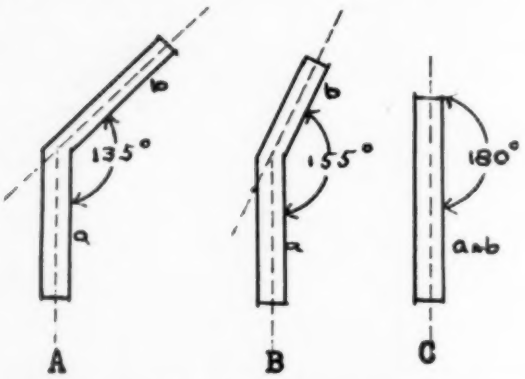

FIG. 1. Changes in projected angulations with rotation of the 135° wire. *A*, the projected angulation corresponds to the real angulation, axis *a* and axis *b* are in the plane of the wall perpendicular to the light ray. *B*, increase of 20° in the projected obtuse angle with 20° of rotation of *a* in the plane of the wall, while *b* rotates out of the plane of the wall. *C*, the projected angulation is a straight angle, *a* is in the plane of the wall, *b* is in a plane perpendicular to the wall.

Method. The study of the shadows projected on a wall from the light of a single light bulb as angulated wires are placed in different planes between the light bulb and the wall affords a simple means of visualizing the different projected angulations. For this purpose will suffice two pieces of double o wire each 8 inches in length, one piece angulated at 135°, and the other at 45°. For reference, perpendicular lines, *xx'* parallel to the floor, and *yy'* perpendicular to the floor are drawn on the wall with their point of intersection *O* exactly perpendicular and 1' distant from the light bulb. Throughout the observations with the wires the position of the reference lines and the position of the light bulb will remain unchanged, and the vertex of the wire employed will always be centered as closely as possible to *O*, the point of intersection of the reference lines, perpendicular to the light bulb.

It should be noted here that for each observation with the wires, the angulation of the shadow on the wall will correspond to that cast on a film if it was substituted for the wall, and the roentgen tube was substituted for the light bulb.

Observation 1. Parallel projection principle; the two axes of the angle *a* and *b* remain in the same parallel plane. The 135° wire is placed with its vertex at *O*, and axis *a* parallel with the *yy'* axis, while axis *b* also remains parallel with the wall. Only in this position with the two axes of the wire parallel to the wall and perpendicular to the light bulb will the angle as measured on the shadow correspond exactly to the real angle of the wire (Fig. 1, *A* and Fig. 2, *A*).

Application 1. The principle applies to the projection of bone angles on the film. For the projected angulation between any bone or bones, such as between the neck and shaft of the humerus, the neck and shaft of the femur, or the angulated fragments of fractures, to correspond to the real angle, their parts must be

placed so that their axes are parallel to the plane of the film perpendicular to the central roentgen ray (Fig. 3, *A*).

Observation 2. One axis of the obtuse angle remains in the parallel plane. With axis *a* of the 135° wire placed parallel to *yy'* and rotated, axis *b* is shifted out of the plane of the wall toward the light bulb, and then away from the light bulb through 360° of rotation. In this manner it can be shown that the more the rotation from the plane of the wall, the more obtuse becomes the angle of the shadow, and when both axes of the wire are in *yy'*, the angle of the shadow

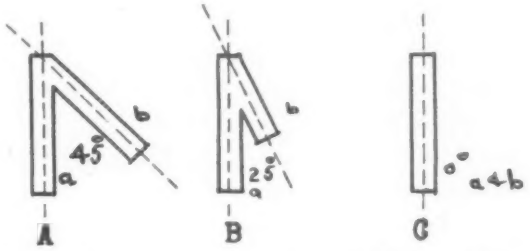

Fig. 2. Changes in projected angulations with rotation of the 45° wire. *A*, the projected angulation corresponds to the actual angulation, *a* and *b* are in the plane of the wall perpendicular to the light ray. *B*, decrease of 20° in the projected acute angle with 20° of rotation of *a* in the plane of the wall, while *b* rotates out of the plane of the wall. *C*, the projected angulation is 0°, *a* is in the plane of the wall, *b* is in a plane perpendicular to the wall.

is a straight angle. In other words, rotation of the obtuse angle about an axis perpendicular to the central roentgen ray always causes the angle to appear more obtuse than 135°, never less (Fig. 1, *B* and *C*).

Application 2. With outward rotation of the axis through the head of the normal humerus or head of the normal femur outside of the plane of the film, while the axis through the shaft remains in the plane of the film, the projected angle will always be more obtuse than the real angle, the increase in degrees of the angle corresponding exactly to the degrees of shaft rotation, and the appearance will be that of valgus deformity, or a real valgus deformity will appear greater than it really is, never less (Fig. 3, *B*, and Fig. 4, *A*). Among fracture angulations, obtuse angulations occur by far the most frequently,[1] and here again with only one axis through one of the fragments remaining in the plane of the film, the projected angulation always appears more obtuse than it really is. In

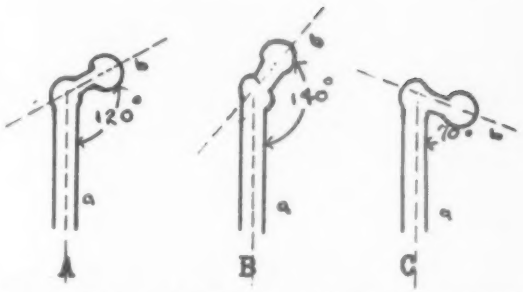

Fig. 3. Real and deformed projected femoral neck angles of the normal femur, *A*, with the axis *a* through the shaft, and *b* through the neck parallel to the plane of the film perpendicular to the central ray, the projected angle on the film corresponds to the real angle 120°. *B*, projection coxa valga deformity. Outward rotation of *a* 20° in the plane of the film, while *b* rotates out of the plane of the film, the projected angle measures 20° more than the real angle. *C*, projection coxa vara deformity. Shaft elevated 75° out of the plane of the film toward the roentgen tube and internally rotated 45° bringing *a* and *b* into oblique planes. Projected angle measures 70°.

other words, the projected deformity always appears less than it really is.

Observation 3. With axis *a* of the 45° wire placed parallel to *yy'* and rotated, axis *b* is shifted out of the plane of the wall toward the light bulb, and then away from the light bulb through 360° of rotation. In this manner it can be shown that the more the rotation from the plane of the wall, the more acute becomes the

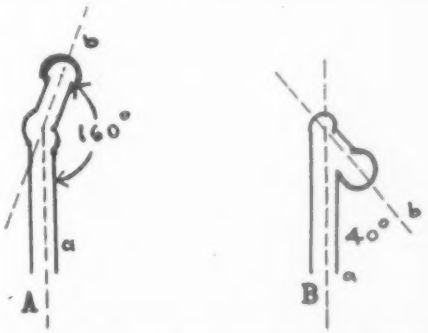

Fig. 4. Exaggeration of real coxa valga and coxa vara deformities. *A*, exaggeration of coxa valga deformity, real femoral neck angle 140°. Outward rotation of *a* 20° in the plane of the film, while *b* rotates out of the plane of the film, the projected angle measures 20° more than the real. *B*, exaggeration of coxa vara deformity, real femoral neck angle 60°. Outward rotation of *a* 20° in the plane of the film, the projected angle measures 20° less than the real.

angle of the shadow, and when both axes of the wire are in *yy'*, the angulation is 0° (Fig. 2, *B* and *C*). In other words, rotation of the acute angle about an axis perpendicular to the central ray always causes the angle to appear more acute than 45°, never less.

Application 3. With varus deformity of the neck of the humerus or neck of the femur when the angle between the neck and shaft is acute, and the axis through the head of the humerus or the head of the femur is outside of the plane of the film, while the axis through the shaft remains in the plane of the film, the projected angle will always be more acute than the real angle, the decrease in degrees of the angle corresponding exactly to the degrees of shaft rotation, and the varus deformity will appear exaggerated (Fig. 4, *B*). Fractures with their fragments at an acute angle, rare as compared with those at an obtuse angle, and having only one, axis remain in the plane of the film, will always show a projeced angle more acute than it really is, thereby exaggerating the appearance of deformity.

Observation 4. The two axes of the angle occupy oblique planes. With both axes of the 45° or 135° wire placed outside the plane of the wall and rotated in various planes of obliquity, shadows may be cast with either wire showing any degree of angulation, acute, obtuse or straight.

Application 4. Bones with normal or abnormal angulations having their axes in oblique planes may show any degree of projected angulation. For example, a normal femur may cast a shadow showing an acute angle or varus deformity of its neck (Fig. 3, *C*).

COMMENT

With the preceding observations in mind, it is apparent that the examiner desiring to secure at least fairly accurate numerical bone angle measurements from the roentgenogram must know the spatial relations between the projected and the real bone axes. This implies an accurate knowledge of the projected appearance of the bones in various planes, a not altogether easy accomplishment, and furthermore it often requires considerably larger films, incurring greater expense, to include more of the bones in the attempt to determine the direction of their axes.

During recent years the writer and his associates have seen these measurements employed more frequently, often by individuals without the least knowledge of the principles involved, with the subsequent expected erroneous results, and with errors in several cases leading to litigation. It would seem, therefore, timely to call attention to the fundamental principles of bone angle projection, and to suggest that the examiner employ the older descriptive methods rather than the numerical, unless he is fully aware of their possibilities and limitations.

SUMMARY

1. Although measurements of projected bone angles are frequently made, the underlying principles concerning their measurement on the roentgenogram have received practically no consideration in the literature.

2. The study of the shadows of angulated wires projected on a wall as they are placed in different planes between a single light bulb affords a simple means of demonstrating the principles of angle projection.

3. Angles are projected in correct size only if their axes are parallel to the plane of the film perpendicular to the central roentgen ray.

4. Obtuse angles with only one axis in the plane of the film are always projected more obtuse than the real angles.

5. Acute angles with only one axis in the plane of the film are always projected more acute than the real angles.

6. Obtuse or acute angles with their axes in oblique planes may show any degree of projected angulation.

7. The practical numerical measurement of bone angles on the roentgenogram requires that the examiner know the spatial relations between the projected and the real bone axes, and this implies an accurate knowledge of the projected appearance of the bones in various planes. Measurements made without this knowledge may lead to serious mistakes.

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REFERENCES

1. BAUER, K. H. Fracturen und Luxationen. J. Springer, Berlin, 1927, p. 24.
2. GARLAND, L. H. The roentgen diagnosis of fractures and dislocations. In: Diagnostic Roentgenology. Ross Golden, Editor. Thomas Nelson & Sons, New York, Vol. 2, Chapter 11.
3. GLASSCHEIB, S. Allgemeine Röntgenkunde. J. Springer, Vienna, 1936, p. 149.
4. SCHINZ, H. R., BAENSCH, W., and FRIEDL, E. Lehrbuch der Röntgendiagnostik. G. Thieme, Leipzig, 1939, Vol. 1, p. 545.
5. VAN NUYS, R. G. Normal bone angles and the roentgen report. *Radiology*, 1940, *35*, 206–209.

MEGADUODENUM SECONDARY TO AN INTRINSIC DUODENAL DIAPHRAGM*

REPORT OF CASE

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CONGENITAL duodenal diaphragm causing congenital duodenal stenosis is a rare condition. This report deals with the ninth instance of an intrinsic duodenal diaphragm appearing in an adult. The case to be described presents a twenty-three year history of duodenal obstruction, beginning at birth, asymptomatic following early childhood, only to recur at the age of twenty-three.

CASE REPORT

G. B., female, white, aged twenty-three, unmarried, was admitted to the Jewish Hospital of Brooklyn on October 24, 1944, complaining of fullness of the abdomen for two days, with slight nausea, but no vomiting or abdominal pain. An enema, given the day before admission to the hospital, had been effectual.

The first two days after her birth, the patient was said to have had repeated projectile vomiting of clear, watery material, which was not related to her feedings. The vomiting diminished in intensity and frequency, occurring once every two weeks until the age of six years, after which there was no further emesis. Roentgenograms of the stomach, taken when she was five years old, showed an abnormality of undetermined nature, for which surgery was recommended. The family, however, refused consent for operative intervention at that time.

The patient's mother reported that at the age of three years the patient ingested some charcoal powder, which appeared in vomitus brought up three months later! The patient also remembered regurgitating a cherry pit which had been swallowed some four months previously. There was never a history of hematemesis, bloody or tarry stools, constipation, diarrhea, abdominal pain or previous distention before the onset of the presenting complaints.

Physical examination on admission, revealed a stocky, well developed, well nourished white female with a soft, nontender, markedly tympanitic and distended upper abdomen. There were no palpable abdominal masses. Rectal examination was noncontributory. The remainder of the physical examination was entirely negative.

Laboratory Findings. Hemaglobin, 77 per cent; red blood cell count, 4.21 million; white blood cell count, 15,200. Differential: 73 per cent polymorphonuclear cells, 3 per cent nonsegmented polymorphonuclear cells, 18 per cent lymphocytes and 6 per cent monocytes. The urine was acid in reaction, with a specific gravity of 1.029, negative for sugar and acetone and had a faint trace of albumin. Microscopic examination revealed an occasional white blood cell. The blood Kline reaction was negative. Blood urea nitrogen was 19.6 mg. per 100 cc.; blood sugar, 91 mg. per 100 cc.; and the blood carbon dioxide content was 69.2 volumes per 100 cc.

Shortly after admission, a Levine tube was passed into the stomach and 3,500 cc. of a dark, brown fluid were aspirated. It was acid in reaction and was positive to the guaiac test. A flat roentgenogram of the abdomen on admission revealed a distended stomach occupying the upper abdomen. No free air under the diaphragm was noted. A barium enema revealed no intrinsic colonic pathology.

A gastrointestinal series (Fig. 1 and 2) demonstrated a J-shaped, somewhat enlarged stomach, with tremendous dilatation of the first and second portions of the duodenum. In the region of the second portion, the dilatation

* From the Radiological Service of Dr. Milton G. Wasch and the Medical Service of Dr. Joseph Rosenthal, The Jewish Hospital of Brooklyn.

ended abruptly in a constriction, which resembled a cord-like, rigid band, a few millimeters in diameter. Below this, the duodenal lumen assumed almost normal dimensions.

Aspiration from the region immediately proximal to the point of narrowing, by means of a Levine tube under roentgen visualization, was productive of a bile-stained material which was acid in reaction.

On November 10, 1944, following seventeen days of treatment with gastric lavage and antispasmodics, an exploratory laparotomy was performed by Dr. Louis Berger. The stomach was enlarged, filling the left hypochondrium and epigastrium. Beyond the pylorus, a huge sausage-shaped dilatation of the duodenum, ending in a tight constriction ring in its second portion, was noted. This ring marked the boundary between the proximal, distended, dilated loop and the normal duodenal lumen beyond. The involved bowel was covered by a thick vascular fibrous tissue apron, which extended from the mid portion of the head of the pancreas to the gallbladder. The cecum and ascending colon were mobile and normal. The liver was displaced upward and backward. The common duct entered the second portion of the duodenum distal to the point of narrowing.

A longitudinal incision was made through the constriction in the duodenum, revealing an intrinsic diaphragm with a central opening which barely admitted the tip of a Kelly clamp. The diaphragm was incised and biopsies of the duodenum were taken proximal and distal to the obstruction. The longitudinal incision in the duodenum was closed transversely in order to widen the lumen at the site of obstruction. The biopsied specimens were identical histopathologically, and were diagnosed as duodenal tissue.

Two months after operation, the patient was asymptomatic and stated that her upper abdomen had shown a marked decrease in size. A gastrointestinal series (Fig. 3 and 4) repeated at this time, revealed a duodenum still much broader than average, but considerably reduced in caliber as compared with that noted preoperatively. The original constriction in the lower portion of the duodenum had been completely overcome, and the lumen restored.

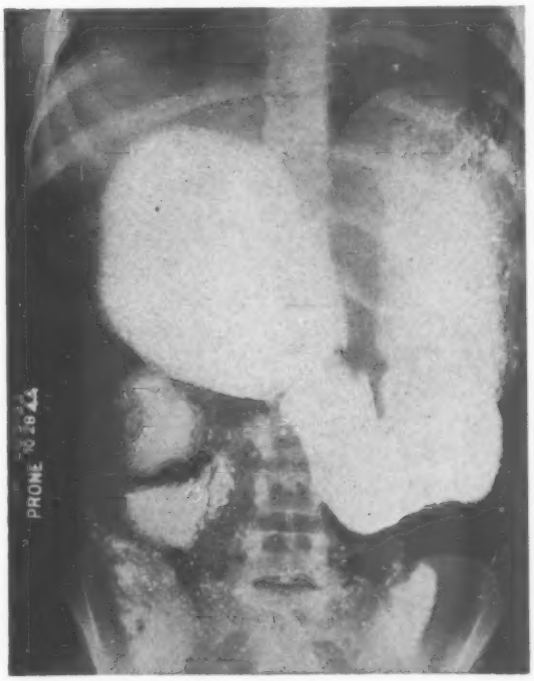

Fig. 1. Barium study, fifteen minutes after ingestion, demonstrating a markedly dilated duodenal bulb.

Fig. 2. Erect oblique view demonstrating the dilated duodenum from pylorus (lower black arrow) to point of stenosis (white arrow). Note the extreme narrowing at the site of stenosis.

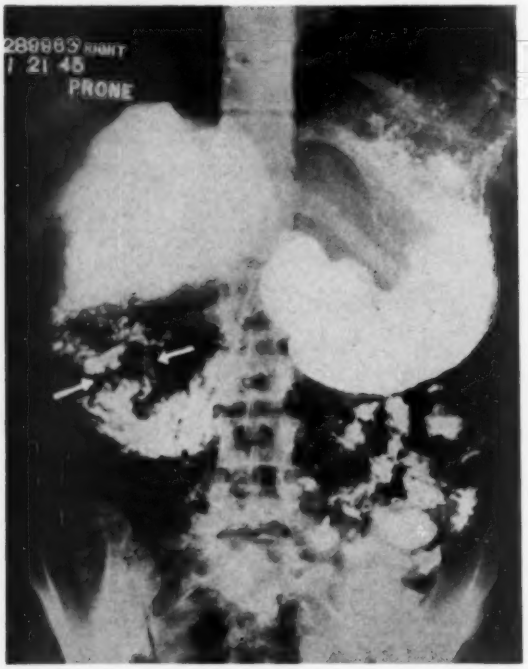

FIG. 3. Barium meal taken three months postoperatively revealed diminution in size of the duodenum and restoration of the lumen at the site of stenosis.

FIG. 4. Postoperative erect view showing marked decrease in size of the duodenal loop as compared with Figure 2. Again, the ample restoration of the lumen at the site of obstruction is demonstrated.

COMMENT

Congenital duodenal obstruction is classified as extrinsic, when caused by aberrant vessels, extrinsic peritoneal bands or malrotation of the gut; and intrinsic, when the obstruction is the result of atresia, stenosis, or an intrinsic diaphragm (Ladd,[3] Forssner[1]).

Peritoneal bands usually occur in the region of the duodenojejunal flexure. One-third of Ladd's series,[3] composed of extrinsic and intrinsic lesions, were due to bands.

The intrinsic obstructions have been attributed to the fact that the primitive gut closes solidly, when the embryo reaches the age of five weeks. This obliteration of the lumen of the gut is the result of the proliferation of epithelial cells. The lumen of the embryonic bowel is soon restored by the formation of vacuoles between the proliferated cells, and the coalescence of these vacuoles to give rise to complete recanalization. At the same time, the gastrointestinal mucosa becomes histologically differentiated. The faulty recession of these cells is said to give rise to stenosis, atresia and congenital diaphragm (Tandler,[7] Ladd[4]).

Atresia of the duodenum usually causes serious symptoms in the first five days of life.[2] Stenosis, where the lumen itself is narrowed by constriction of the wall, rather than by an intrinsic diaphragm, has not been reported in any case above the age of three years (Krieg[2]). Hypertrophic pyloric stenosis, which may be confused with duodenal obstruction, is usually seen in male, first-born infants, though it has been seen in adults.

Krieg,[2] summarizing the literature, found 21 cases of diaphragmatic obstruction diagnosed in individuals of all ages, varying from the fetus of several months' gestation to the septuagenarian. Nagel[6] cites 7 cases of duodenal diaphragm in adults. Krieg cites an eighth adult case of this type. After

review of the literature, we believe ours to be the ninth.

The time of the appearance of symptoms varies. Krieg points out that 38 per cent present symptoms during the first two weeks of life; 10 per cent develop symptoms between the third and eighth month; 24 per cent, between the ages of one and eight years, and 29 per cent after twenty-four years. These statistics are based on his tabulation of the 21 reported cases of duodenal diaphragm. The same author listed the location of the diaphragm as follows: proximal to the ampulla of Vater, 45 per cent; opposite the ampulla, 20 per cent; distal to the ampulla, 25 per cent; and at the duodenojejunal junction, 10 per cent. The diaphragm microscopically is usually composed of mucosa and submucosa, with smooth muscle fibers seen on rare occasions. It has very rarely been imperforate.[2]

In infants, the most pronounced symptom of duodenal obstruction is persistent vomiting. Abdominal distention is noted in varying degree. Visible peristalsis and a palpable dilated duodenum may at times be part of the physical findings. The stools are diminished in number and size, and there is vomiting and dehydration. Loss of weight or failure to gain weight are common, and often infants are brought into the hospital for regulation of feeding. In older children, there is often the complaint of intermittent abdominal pain (Ladd and Gross[5]). Roentgen examination, with or without contrast media, will often reveal the dilated upper intestinal loop above the point of obstruction, and will thus locate the site of the lesion.

Ladd and Gross[5] recommend preoperative preparation with adequate parenteral fluids and decompression of the upper intestinal tract. They prefer a short-circuiting anastomosis to dilatation or incision of the diaphragm, if such is the nature of the primary lesion. Gastrojejunostomy is advised by these workers for obstructing lesions above the papilla of Vater; and duodenojejunostomy, in all other types of duodenal obstruction. Finally, they point out the uniform fatality of enterostomy. The surgical procedure followed in the case presented in this report, however, was essentially a dilatation and incision of the diaphragm with transverse suture of the longitudinal incision made in the gut. The result has been very satisfactory to date.

SUMMARY

1. A case of duodenal obstruction secondary to congenital duodenal diaphragm is presented.

2. The embryology of congenital duodenal obstruction is summarized.

3. Congenital duodenal obstruction, in relation to its localization, diagnosis and treatment, is discussed.

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The authors wish to express their appreciation to both Dr. Wasch and Dr. Rosenthal, for their advice in the treatment of this case and the preparation of this report.

REFERENCES

1. Forssner, H. Die angeborenen Darm und Oesophagusatresien. *Anat. Hefte*, 1907, *34*, 1060.
2. Krieg, E. G. Duodenal diaphragm. *Ann. Surg.*, 1937, *106*, 33–41.
3. Ladd, W. E. Congenital obstruction of the small intestine. *J. Am. M. Ass.*, 1933, *101*, 1453–1458.
4. Ladd, W. E. Congenital duodenal obstruction. *Surgery*, 1937, *1*, 878–885.
5. Ladd, W. E., and Gross, R. E. Abdominal Surgery of Infancy and Childhood. W. B. Saunders Co., Philadelphia, 1941.
6. Nagel, G. W. Unusual conditions in the duodenum and their significance. *Arch. Surg.*, 1925, *11*, 529–549.
7. Tandler, J. Über die Entwicklung des menschlichen Duodenums in frühe Embrionalstadien. *Morphol. Jahrb.*, 1900, *24*, 187–216.

DIVERTICULUM OF THE CARDIA OF THE STOMACH

REPORT OF THREE CASES

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IN A SERIES of one thousand consecutive barium meal examinations, 3 cases of true diverticulum of the fundic end of the stomach were encountered. One of these has been previously reported and the importance of the supine and Trendelenburg examination was stressed.[1] Two new cases are added and these show the common site of the diverticulum on the posterior aspect of the stomach below the entrance of the esophagus into the stomach, close to the lesser curvature. Available statistics indicate that about 155 cases have been reported thus far in the literature.

Diverticula of the intestinal tract are a common entity. The esophageal pouches were early described in the English literature. Large bowel diverticulosis is most frequently encountered and usually receives adequate consideration, in differentiation from malignancy, acute appendicitis, and tuberculous or ulcerative colitis and ileocolitis. The duodenum is the second most common site. These diverticula are often seen in routine roentgenoscopy of the stomach and are less frequently missed because of the attention given to the duodenal segment, the site of the prevalent duodenal ulcer. The jejunum and jejunoileal region are still less common sites for diverticulosis, probably on a par with the stomach in incidence. Closer scrutiny of the fundic portion of the stomach should be made. In this series the majority of whom were soldiers in the United States camps, only 16 cases of gastric ulcer were diagnosed roentgenologically. The pro rata frequency of diverticula of the fundus compared with gastric ulcer in this series should serve to emphasize the need for examination of the cardia more closely.

In the cardia, in common with diverticula elsewhere, inadequate musculature is probably the etiological factor. The cardia compared to the muscle layers elsewhere in the stomach is not as well coated. The circular and oblique fibers are thinned out. Keith[2] believes the musculature of the stomach around the cardiac orifice is inherently weak and that increased intra-abdominal pressure and straining are factors in their development. The passage of ducts and large blood vessels through the wall may predispose to these pouches. It would also appear that diverticula are prone to occur at sites of incomplete peritoneal covering. These are seen in the colon, accompanying fat pads in the appendices epiploicae lifting the peritoneum, in the duodenum at the site of adjacent pancreatic tissue where the peritoneum is deficient, and at the cardia at the lesser curvature aspect where the peritoneum is reflected in the formation of the lienorenal and gastrosplenic ligaments. Here the left gastric artery, a branch of the celiac, passes upward to the left behind the peritoneum of the lesser sac, turns forward and gives large branches to the esophagus and cardia. An increase in the intragastric pressure and poor intrinsic muscle tone may be contributing factors. It is interesting to note that diverticulosis of the colon and duodenum are often observed together. Many have been reported. In none of these cases of diverticulum of the cardia were other diverticula noted.

The classification of diverticula commonly used is: true or congenital types, and the acquired or false types, depending on the presence or absence of all the muscle coats. As for the incidence of gastric diverticula, variable statistics have been offered. In routine autopsies, Rivers, Stevens and Kirklin[3] cite 4 cases in 3,662, an incidence of 1 in 914. These authors state that 4 of 6 of their cases in which a diagnosis had been diverticulum, at exploration

these diverticula were found to be false sacs due to malignant disease or perforating ulcer. Roentgenologically and clinically the diagnosis may be difficult. A perforating gastric ulcer with an accessory pocket may simulate a diverticulum. Ordinarily, ulcers are rare at the typical site of diverticula. The duration of complaints, periodical character, gastric analysis and pertinent roentgenological features usually suffice for diagnosis. Tenderness elicited over the pouch where the site can be reached and the rate of emptying are of clinical significance. The diverticulum has a smooth periphery, is usually rounded, and has a narrow pedicle, is flask-like in the tangential projection, and shows the stomach mucosal pattern (Fig. 1 and 3). Occasionally a fluid level is observed (Fig. 2). In contrast the ulcer niche usually arises by a broad base and will respond to treatment when benign. An early re-examination is indicated to observe recrudescence of the benign ulcer niche following treatment. The features of the malignant ulcer are infiltration of the wall, often with a subtraction defect, distorted air bubble, lack of peristalsis, fixation and rigidity, meniscus sign, and failure to respond to medical treatment. Assisting in the diagnosis is the hypochlorhydria accompanying most cases of carcinoma.

Templeton[4] states that a cascade stomach with a redundant posterior portion may simulate a true diverticulum. In this series 2 such cases were encountered. However, differentiation was not difficult; 1 of these patients was an air-swallower. Roentgenologically no true stalks were present and the pseudodiverticulum easily identified. On subsequent examination in both cases the size and character of the pouches observed varied sufficiently to indicate they were redundant pouches rather than true diverticula.

Stomach herniation through the diaphragmatic esophageal aperture may give some difficulty in differential diagnosis from diverticula. According to Pendergrass,[5] by observing the effects of inspiration and expiration on the size of the pouch, a diagnosis can be made. Hernias increase in size in the inspiration phase and decrease upon expiration. No similar phenomenon is observed in diverticulum and these 3 cases showed no change in size in quiet or forceful respiration. Diverticulum of the cardia is usually parallel to the superior and inferior surfaces of the vertebral bodies (Fig. 1 and 2), while gastric hernias are apt to be angulated.

Diverticula are often found in routine examinations and are known to be asymptomatic. In these 3 cases the histories are ulcer like and no other evidence of organic disease was noted. All 3 cases give a history of epigastric pain and in 2 the onset of pain follows ingestion of food by about an hour. In the third case the epigastric pain seems to have no relation to food. In 1 of the cases a change in position gives definite relief. None gives a history of hematemesis or melena, one of the more frequently reported complications.

None of these cases was considered for surgical removal of the sac because of the classical site of the lesion and improvement under conservative treatment. Prevalent opinion is that surgery is indicated where diagnosis is in doubt or treatment is ineffective. This applies particularly to those lesions somewhat lower in position as these may be false sacs due to malignant disease or benign ulcer.

CASE REPORTS

CASE I (Fig. 1). Previously reported.[1] A male, aged twenty-three, complained of epigastric pain, nausea, and eructations of twenty-four hours' duration. He has had similar attacks at intervals for the past two years. Onset of pain one hour after meals. Relieved by food and alkali. Physical examination and gastric analysis essentially negative. Diverticulum emptied in twenty-four hours.

CASE II (Fig. 2). Male, aged fifty-five, complains of burning pain and eructation, epigastric in site, about one hour after food. He has had periodic gastric discomfort for the last few years. Pain is relieved by belching or change in position. Medication is occasionally helpful.

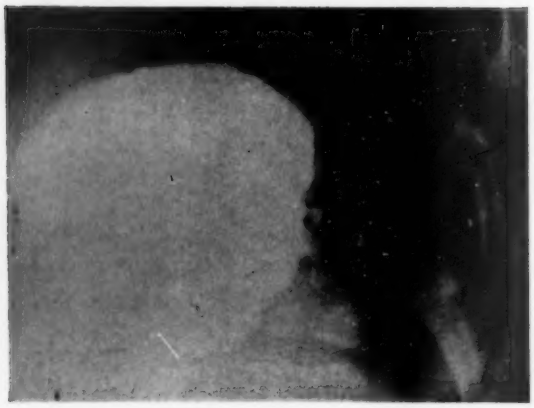

FIG. 1. Case I. Tangential projection showing unfilled diverticular sac, posterior to the cardia, mucosa stained with medium.

Weight is constant, appetite good, physical examination is essentially negative. Some local tenderness was elicited and diverticulum was empty at six hours.

CASE III (Fig. 3). Female, aged twenty-three, complains of epigastric pain and flatulence, duration one and one-half years. Periods of discomfort during this time have recurred six or seven times. Duration of each attack is approximately four days. The present attack has lasted for a week. Pain has no definite time relation to food, but is often aggravated by eating. No history of dysphagia, anorexia, loss of weight, icterus, acholic stools, hematemesis, or melena. Habits are not contributory; a moderate smoker, occasional drinker. Physical examination essentially negative. Basal metabolism and gastric analysis were normal. The diverticulum was empty at six hours and no tenderness was elicited as the fundus was too high for palpation.

FIG. 2. Case II. Tangential projection showing neck eccentric to pouch and fluid level.

FIG. 3. Case III.

SUMMARY

Three cases of diverticulum of the stomach are presented with roentgenographic studies and discussion.

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REFERENCES

1. RESNICK, B. Report of case of diverticulum of stomach (cardia). *Am. J. Digest. Dis.*, 1943, *10*, 380–381.
2. KEITH, A. Diverticulum of alimentary tract of congenital or obscure origin. *Brit. M. J.*, Feb. 12, 1940, *1*, 376.
3. RIVERS, STEVENS and KIRKLIN. Quoted by Bockus, H. L. Gastro-enterology. Vol. 1, p. 770, 1943.
4. TEMPLETON, F. E. X-Ray Examination of the Stomach. University of Chicago Press, Chicago, 1944, pp. 463–465.
5. PENDERGRASS, E. P. Diverticulum of upper end of stomach. *Surg. Clin. North America*, 1931, *11*, 1493–1496.

OSTEORADIONECROSIS OF THE MANDIBLE*†

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OSTEORADIONECROSIS is a pathological process which sometimes follows heavy irradiation of bone and is characterized by a painful, prolonged course, late sequestration of bone, and occasional permanent deformities. It is not an uncommon complication particularly in the mandible after radiation treatment of oral carcinoma. When it occurs, the macroscopic structure of bone may be retained, but if infection enters the bone, an indolent destructive process develops which culminates after many months or even years in sequestration and healing. Its pathogenesis is not clearly understood probably because investigative studies with heavy protracted fractionated irradiation have not yet been reported. Therefore neither its prophylaxis nor its therapy is based on sound facts.

Watson and Scarborough[1] have stated that in a series of 1,819 patients with intraoral carcinoma or allied conditions there were 235 in whom osteoradionecrosis was demonstrated, or an incidence of 12.9 per cent. The serious aspects of the problem are emphasized by the facts that 12 of the 235 died as a direct result of the necrosis without evidence of cancer and that the average period of incapacity in 204 patients treated conservatively was 11.1 months. They, and others,[2] state that there are three related factors in the production of this complication: irradiation, infection, and trauma. Necrosis can follow heavy irradiation alone, but it is more common when there is a concomitant or post-irradiation infection in the mouth, particularly in and about the teeth. It also occurs after teeth have been extracted from an alveolus which has been damaged by radiation therapy.

In a recent series of patients with cancer of the oral cavity[3] there were several examples of this complication which emphasize certain criteria in its prophylaxis and definitive therapy.

CASE 1 (A80727). J. T. The patient was a white woman, aged sixty-nine, who was admitted to the Tumor Clinic on September 21, 1937, complaining of a swelling of the left upper lip of four months' duration. At the time of its onset she noticed that the skin of the lip was swollen and that the mucous membrane was roughened. A tumor nodule appeared in the roughened area five weeks before admission. Examination on admission showed a granular, raised area on the buccal surface of the left side of the upper lip, 2 cm. in diameter. It had grown directly through the lip to the skin where there was a raised nodule 1.25 by 1.5 cm. in size. The biopsy of the mucosal surface showed squamous cell carcinoma, Grade 2. The lesion was treated with roentgen therapy from September 29 to October 29, 1937. The radiation factors were 100 kv. (peak); filter, 1 mm. Al; 3 ma.; and 23.5 cm. distance. Two fields were used, an intraoral, 2 cm. in diameter, and an external field, 4 cm. in diameter, located directly over the tumor in the skin. The former field was given 3,297 r, measured in air, and the latter, 3,748 r. She was admitted to the hospital on January 12, 1938, because of recurrent tumor in the lateral portion of the original tumor area. It was treated with a radium moulage. One hundred milligrams were used. The distance was 0.5 cm. and the filter, 0.2 mm. of platinum. The size of the treated area was 15 square centimeters. The dose was 1,700 mg-hr. On February 22, 1938, a suspicious nodule was noted on the posterior edge of the original tumor area in the buccal-gingival fold. Later it became definite and on March 27, 1938, eight 2.2 mc. gold radon seeds were implanted. In July, 1938, the alveolar process of the maxilla became exposed. Pain was marked and continued for many months. On March 11, 1941, a portion of the necrotic bone was excised, opening the maxillary antrum from which a small amount of pus escaped. After that she was reasonably comfortable. In

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FIG. 1*a*. Case II. Destructive process in the left mandible at time of admission, March 25, 1940. Destruction probably due to cancer.

August, 1944, a sequestrum 1 by 2 cm. in size was removed with forceps from the margin of the oromaxillary sinus. The sinus remains clean, and there is no evidence of recurrent tumor, but a small portion of the maxillary alveolus remains exposed. The patient has no complaints.

Comment. The etiological agent in this complication was nothing other than heavy irradiation. It is interesting that the sequestrum did not become loose enough to be extracted until six years after the alveolus first became exposed, and it is important to point out that no attempt was made to dislodge it.

CASE II (B4066). J. M. This Polish woman, aged seventy-six, was admitted to the hospital on March 25, 1940, complaining of an infected jaw bone. Five months previously a painless ulcer had appeared on the left lower alveolus and had grown slowly. Examination of the mouth showed an indurated, firm mass, 1 cm. in diameter, on the lateral border of the middle third of the left lower alveolus. It had a central shallow ulcer 5 mm. in diameter. Biopsy showed a squamous cell carcinoma, Grade 2. Roentgenograms of the mandible on March 26, 1940 (Fig. 1*a*) showed a destructive process in the body of the mandible interpreted as being due to invading carcinoma. She was treated with roentgen therapy from April 4 to 24, 1940, through two fields, an intraoral and a left oblique mandibular field. The radiation factors for the former were 200 kv. (peak); filter, 0.25 mm. Cu and 1 mm. Al; 20 ma.; 56 cm. distance and 300 r, measured in air, a day. For the latter field, the factors were 200 kv. (peak); filter, 0.75 mm. Cu and 1 Al; 20 ma.; 50 cm. distance, and 307 r, measured in air, a day. The tumor dose was 5,521 r, of which 3,083 r were given intraorally. There was a severe mucositis. Roentgenograms of the mandible on June 20, 1940, and again on January 1, 1941, showed an increase in size of the invasive lesion and on February 11, 1941, a pathological fracture (Fig. 1*b*). A jaw resection was strongly advised, but the patient would not give her consent. A biposy of the questioned area through an extraoral incision was performed on February 28, 1941, but was negative for tumor. No further therapy was administered. She was admitted to the hospital on August 27, 1943 (Fig. 1*c*), for

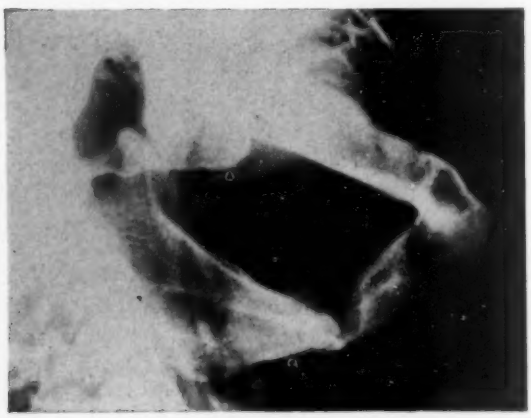

FIG. 1*b*. Case II. Pathological fracture. The fracture occurred ten months after the conclusion of roentgen therapy.

FIG. 1*c*. Case II. The destruction as it appeared on August 27, 1943, three years and four months after treatment had been completed.

incision and drainage of a subcutaneous abscess beneath the body of the left mandible. On November 9, 1943, she again entered the hospital, this time with an ulcer on the left margin of the tongue 1 cm. in diameter. It had not been present at her last visit to the Tumor Clinic one month previously. A biopsy showed squamous cell carcinoma, Grade 1. The lesion was excised. There has been no recurrence of either tumor and the last roentgenograms show no

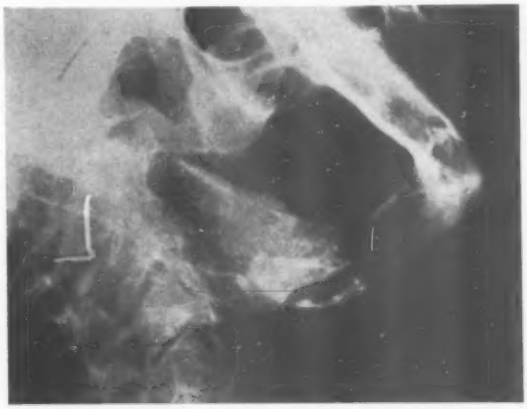

Fig. 1*d*. Case II. Condition on November 7, 1944. There has been no further destruction but no involucrum formation.

essential change (Fig. 1*d*). A small segment of bone remains exposed in the alveolus.

Comment. Neither infection nor trauma contributed in any way to the necrosis, the etiological agent being entirely heavy irradiation. The original mandibular defect was undoubtedly due to carcinoma which was controlled by roentgen therapy. In retrospect, it is somewhat surprising that the trauma of the biopsy did not accelerate the radionecrosis.

Case III (B10877). A. I., male, aged seventy-two, was admitted to the Tumor Clinic on January 2, 1941, complaining of an ulcer beneath his tongue of six weeks' duration. In the floor of the mouth just posterior to the alveolus and to the left of the midline there was an ulcerated area measuring 1 by 1.5 cm. with a surrounding zone of induration. Biopsy showed squamous cell carcinoma, Grade 1. There were extensive dental caries, pyorrhea and gingivitis, but the patient steadfastly refused to have his

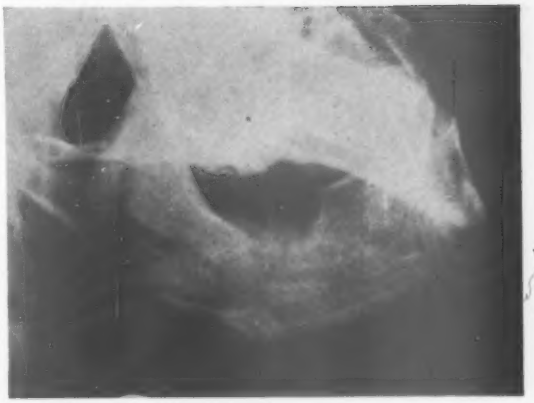

Fig. 2*a*. Case III. December 20, 1941. Early destruction of the alveolar process of the left mandible.

teeth extracted. Roentgen therapy was started on January 14, 1941, through two external mandibular fields, 6 cm. in diameter, directed obliquely toward the floor of the mouth. The radiation factors were 200 kv. (peak); filter, 0.75 mm. Cu and 1 mm. Al; 20 ma.; and distance 50 cm. During therapy the mouth infection became so severe that on January 25, 1941, the patient refused to return for treatment. He was finally hospitalized on February 3, 1941, and during the next week all of his teeth were extracted. Roentgen therapy was resumed on February 11, 1941, and concluded on February 26, 1941. An intraoral cone was used in this latter period. The irradiation factors were the same as for the external fields except that the filter was 0.25 mm. Cu and 1 Al and the distance was 56 cm. The tumor dose was 6,475 r, 1,606 r being delivered through the intraoral cone. The mucositis and epidermitis were moderate. Three

Fig. 2*b*. Case III. March 20, 1942. Pathological fracture of the mandible.

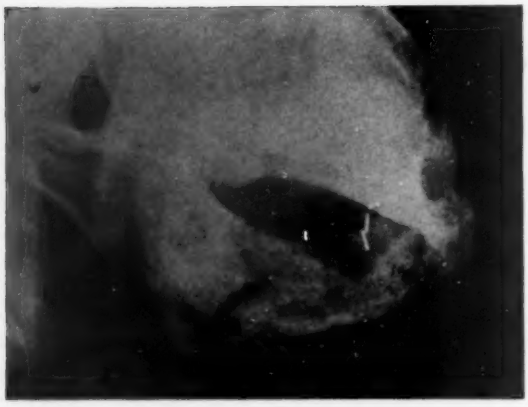

Fig. 2c. Case III. May 21, 1942. Further extension of the destructive process.

1 millicurie radon seeds were inserted into the residual tumor area on May 3, 1941.

Sequestration of the mandible was noted for the first time on July 17, 1941, when several small fragments of bone were removed. A portion of the right maxilla sequestrated and was removed in November, 1941.

In December, 1941 (Fig. 2), he was admitted to the hospital for incision and drainage of a soft tissue abscess below the body of the left mandible. During the same period of hospitalization portions of the anterior mandible involved by osteomyelitis were rongeured away on three different occasions. Eventually the mucous membranes retracted from the mandible. On July 29, 1942, he was admitted with the mandible completely exposed back to each ramus. It was removed. He died of heart disease on April 25, 1943. An autopsy failed to reveal any remaining carcinoma.

Comment. It is obvious, in retrospect, that this patient was improperly handled in several ways. The most important deficiency was due to the patient's obstinacy in refusing to allow his teeth to be extracted before irradiation was started. It seems certain that with the severe degree of dental infection he ultimately would have had necrosis. It might have been wiser to have cut the teeth off at the gingival border when the infection became severe rather than to have extracted them. It is also rather doubtful if the mandible could have been saved by more conservative methods; but it is possible that, if the sequestrum had been removed only as it loosened, less bone would have ultimately become necrotic and what remained might have been stabilized by a fibrous tissue union.

All three etiological factors contributed to the necrosis: heavy irradiation, infection from carious teeth, and trauma from tooth extraction.

Case IV (A88370), H. F., male, aged forty-two, was referred to the Tumor Clinic on June 1, 1939, because of an ulcer of the hard palate that was found on routine physical examination. A biopsy showed chronic inflammation. He then refused to answer follow-up appointments but returned voluntarily on February 11, 1941, complaining of severe pain in the roof of his mouth. An ulcerated lesion of the right hard palate 2 by 3 cm. in size was found. Biopsy showed squamous cell carcinoma, Grade 2. His teeth were in poor condition. The worst ones were extracted before irradiation was instituted, but through a misunderstanding others were removed two weeks after therapy. He was treated with roentgen therapy from March 12 to April 25, 1941. Two external fields, 6 cm. in diameter, and an intraoral cone, 2 cm. in diameter, were used. The irradiation factors for the former fields were 200 kv. (peak); filter, 0.75 mm. Cu and 1 mm. Al; 20 ma.; and distance, 50 cm. For the intraoral cone they were the same except that only 0.5 mm. of copper was used, and the distance was 56 cm. The daily dose was 275 r and 301 r, measured in air, re-

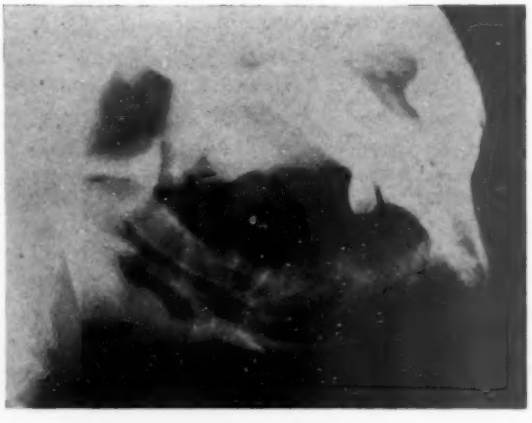

Fig. 3. Case IV. Sequestrum of the ramus of the left mandible.

spectively. The tumor dose was 6,601 r. There was a lapse from March 29 to April 5, when the patient refused to come for treatment because of a sore mouth due to mucositis and painful tooth sockets. He had severe epithelitis. A portion of the right maxillary bone became exposed in May, 1941. Six 1 millicurie radon seeds were inserted into a residual tumor area at the junction of the right hard and soft palate on July 29, 1941. Necrotic slough of the palate appeared on October 28, 1941, and an oromaxillary fistula on November 6, 1941. He began to develop pain and trismus in the left temporomandibular joint on August 21, 1942. An enlarged right cervical lymph node was found in December, 1942. A biopsy of it was positive for metastatic carcinoma, and roentgen irradiation was given, with its subsequent disappearance. On February 23, 1943, he was admitted to the hospital for removal of a sequestrum from the left mandible (Fig. 3). After this the pain in the mandible disappeared and the trismus improved. He continued to have the right oromaxillary fistula but there was no further evidence of remaining diseased bone. The node in the right side of the neck recurred and a right radical neck dissection was done on September 15, 1943. Six months later metastatic tumor reappeared in the neck, and the patient died of disease on August 9, 1944.

Comment. All of the teeth should have been removed before irradiation was started and none at all during the course of therapy. It was also unwise to insert radon when bone was already exposed. Heavy irradiation and infection were probably the most important factors in this patient's complication.

Case v (A99380). J. E., white male, aged eighty-one, was admitted to the hospital on April 23, 1941, complaining of aching pain in the right cheek of three years' duration. During this period he had been treated intermittently for ulcerated leukoplakia of the right buccal mucous membrane at its junction with the posterior portion of the lower alveolus. In this area there was an ulcer, 1 cm. in diameter, surrounded by red, fissured mucous membrane. Biopsy showed a squamous cell carcinoma, ungraded. There were six ragged teeth anteriorly in the lower jaw which he refused to have removed. He was treated with roentgen irradiation from April 24 to June 23, 1941, through

Fig. 4*a*. Case v. Sequestrum of the right mandible with pathological fractures.

two fields, a 6 cm. external field and a 2 cm. intraoral cone. The factors for the first field were 200 kv. (peak); filters of 0.75 mm. Cu and 1 mm. Al; 20 ma.; and 50 cm. distance; for the second field they were 200 kv. (peak); filters of 0.25 mm. Cu and 1 mm. Al; 20 ma.; and 56 cm. distance. The fields were treated on alternate days, and the daily dose was 235 r and 226 r, measured in air, respectively. The tumor dose was 8,575 r, of which 6,116 r were given intraorally. Epidermitis and mucositis were of a moderate degree. The treatment period was prolonged partly because of the fact that he developed unexplained gastrointestinal bleeding requiring two interruptions in therapy of one week's duration each. He was readmitted to the hospital on November 26, 1942, with cellulitis of the right cheek and a necrotic ulcer in the tumor area. The cellulitis subsided but the ulcer persisted. For the following year he sought treatment elsewhere and when he returned in December, 1943, the posterior bony portion of the body of the right mandible was exposed. Roentgenograms showed destruction of bone and a pathological fracture (Fig. 4*a*). The involved area was clean but food collected around the exposed bone. It was treated only with saline irrigations for local cleanliness. There was gradual retraction of the mucous membrane around the sequestrum. In August, 1944, the sequestrum loosened and was easily removed.

FIG. 4*b*. Case v. Defect in the mandible after removal of the sequestrum. An involucrum has not formed.

The defect is now healed satisfactorily (Fig. 4*b*).

Comment. As in Cases I and II, there were no other contributing factors except irradiation which in this instance was excessive. Although teeth were removed following treatment, none of them were in the fields of irradiation and their removal probably was not related to the production of the necrosis. This case emphasizes the prolonged morbidity sometimes encountered. The patient suffered intense pain for several months, and the sequestrum could not be removed for nearly two years after necrosis of the mucous membrane in the tumor area appeared. It also illustrates conservatism in therapy. The patient was instructed in the use of irrigations of the involved area and faithfully visited the clinic weekly for this purpose as well as carrying on the therapy at home. The infection did not spread. No attempt at all was made to remove the sequestrum until it was loose and could easily be extracted with forceps.

CASE VI (B2913). J. B. This patient was a male, aged fifty-three, who was first seen in the Tumor Clinic on November 18, 1940, with leukoplakia of the mouth, chiefly in the mucous membrane of the left lower alveolus, left cheek and left side of the hard palate. A biopsy of an area on the lower alveolus was negative for tumor. He was treated intensively with vitamins and during the next two months three carious teeth were extracted. In May, 1941, another biopsy of a suspicious inferior alveolar lesion in the midline, anteriorly, was positive, showing squamous cell carcinoma, Grade 2. The four lower incisor teeth were extracted to facilitate the use of an intraoral cone in roentgen therapy. The second right lower incisor was fractured from the root during extraction and the root was not removed. Three days later, on May 26, 1941, roentgen therapy was started using a single intraoral cone, 2 cm. in diameter, directly on the lesion. Daily treatments were given until June 25, 1941. The radiation factors were 200 kv. (peak); filters of 0.25 mm. Cu, and 1 mm. Al; 20 ma., and 56 cm. distance. The tumor dose was 5,060 r. The tumor responded well and disappeared. In March, 1942, a second oral carcinoma on the hard palate was found. It was also treated with roentgen radiation with equally good results. In December, 1943, the patient complained of a purulent discharge from the alveolar border of the symphysis of the mandible where a sinus was found in the mucous membrane which extended down to bone. Roentgenograms of the mandible showed the incisor root fragment, sequestration, and a peri-apical abscess. The root fragment was extracted. The sinus was treated solely with saline irrigations. On February 29, 1944, the patient was admitted to the hospital for incision and drainage of a submental soft tissue abscess probably originating from the bone. Gradually over a period of months, the sequestrum loosened and on June 6, 1944, it was removed with forceps. The bed healed slowly, finally becoming completely healed on August 19, 1944. The patient is alive and well without evidence of recurrent disease.

Comment. The importance of the retained fragment of tooth was overlooked when irradiation was started. Undoubtedly the peri-apical abscess that developed about it contributed to a great degree to the infection and necrosis of the alveolar bone that had already been heavily damaged by irradiation. The institution of radiation therapy should have been delayed longer than

three days to allow for healing of the tooth sockets.

The above cases are summarized in Table I.

DISCUSSION

The unique structure of the small bones of the face, particularly of the mandible, and their intimate proximity to the treatment fields probably are the major factors in the high incidence of radionecrosis in this area. The mandible is a ribbon-like structure obtaining its blood supply from a single nutrient artery, the inferior dental artery, and from the periosteum. It is formed of dense compact bone with a calcium content that is 85 per cent of its mineral content.[2] Because of this high calcium content the actual intensity of a given dose of radiation is probably greater in bone than in the overlying skin and mucous membranes. Warren[4] states that adult bone is probably more sensitive to radiant energy than skin and mucous membrane. However, the mineral content of bone causes an increased amount of soft, scattered radiation resulting in a high, total intrinsic dose that is probably not entirely shared by the adjacent soft tissues. Because of their closeness to the skin surface the small bones of the face, by and large, are subjected to higher doses than any others in the body.

Ewing[5] describes new subperiosteal bone developing around the shafts of femurs that had been given heavy doses of radiation. It could be stripped off easily, leaving a granular bony surface and resembled an involucrum forming about a sequestrum. Microscopically, the cell spaces of the bone appeared large and irregular. The canaliculi were also large, widened, irregular and reduced in numbers. Numerous abnormal

TABLE I

Patient	Roentgen Treatment Period	Number of Treatment Days	Therapy			Tooth Extraction	Morbidity Period	Remarks
			Roentgen Ray Tumor Dose	Radium (mg-hr.)	Radon (mc.)			
I. J.T.	Sept. 29 to Oct. 29, 1937	23	7045 r	1700	17.6	—	6 yr.	Severe pain for many months
II. J.M.	Apr. 4 to Apr. 24, 1940	16	5521 r	—	—	—	4 yr., 9 mo.	Relatively mild symptoms. Soft tissue abscess
III. A.I.	Jan. 14 to Feb. 26, 1941	26	6475 r	—	3.0	Yes; during therapy	1 yr.	Marked pain. Multiple soft tissue abscesses. Loss of mandible
IV. H.F.	Mar. 12 to Apr. 25, 1941	27	6601 r	—	6.0	Yes; during therapy	16 mo.	Marked discomfort
V. J.E.	Apr. 24 to June 23, 1941	39	8575 r	—	—	Yes; after therapy	1 yr., 9 mo.	Severe pain
VI. J.B.	May 26 to June 25, 1941	23	5060 r	—	—	Broken root allowed to remain in treatment area	7 mo.	Soft tissue abscess

spaces appeared between the lamellae, and the lamellar substance appeared hyalinized and brittle. Ewing concluded that these changes signified severe degeneration of bone cells, destruction of cell processes, closure of many canaliculi and changes of an undetermined nature in the lamellar substance.

Also in the studies on the femur, Warren[4] states that microscopically there is extreme obliterative endarteritis, rarefying osteitis, absorption and partial loss of calcium and a foreign body giant cell reaction about fragments of necrotic bone. With respect to the jaws, he states that a pure irradiation effect is seldom seen but that infection enhances the damage to bone. Four points are emphasized: (1) The damage may occur beneath intact skin and mucous membrane. (2) The macroscopic integrity of bone is maintained even after exposure to heavy radiation. (3) Infection or trauma added to radionecrosis produces marked gross disintegration of bone. (4) Sequestration in radionecrosis is slower than in necrosis due to trauma or infection. Warren goes on to state that the radiosensitivity of bone is probably due to the calcification of the supporting substance rather than to the direct effect of irradiation on bone cells. The secondary rays act mainly on the lamellar substance, changing in some way its physical constitution without, however, producing gross evidence of change as long as the bone remains free from trauma and infection. Its macroscopic integrity is explained by the presence of an amorphous mineral foundation and by the extreme slowness of the normal changes in bone.

Watson and Scarborough[1] emphasize that periosteum is highly susceptible to irradiation and state that the osteoblasts may be completely destroyed thus explaining the lack of bone regeneration after sequestrectomy or subperiosteal bone resection.

It is apparent from the above discussion that bone is prepared for osteoradionecrosis by heavy external irradiation which causes intrinsic damage to the bone. This damage will usually not become apparent, however, unless it is associated with trauma to the bone or infection or both. Quite naturally the source of trauma and infection is usually related to the teeth and raises the question of management of teeth before irradiation is instituted. Some authors[6] believe that it is necessary to remove teeth only in the direct field of irradiation while others[2] state that all teeth should be sacrificed. This does not mean that only poor teeth should be extracted. It means that the sound should be taken out as a prophylactic measure along with the poor. Only in this way can one be sure that there will be no danger of an infection arising on this basis in the heavily irradiated bone. Case III is an example of the dire results that can follow.

The number of teeth to be removed is a debatable question. Should one extract teeth only in the direct beam of the roentgen rays or should all the remaining ones in the mouth be sacrificed? In an ideal situation where an intraoral cone can be combined with a small external field or with interstitial radon it probably is necessary to remove only the teeth in the direct beam of radiation or that interfere with the precise use of the cone. The following example illustrates the problem: This patient had a carcinoma of the lateral border of his tongue. His teeth were solid and sound. Only the ones that interfered with the intraoral cone were extracted. Two years later all of the remaining teeth suddenly became carious (a situation not uncommon after irradiation affecting the mouth) and had to be extracted. This was done with no little trepidation for fear the trauma and subsequent infection in the teeth sockets would cause disintegration in bone irradiated by the single external field, but such was not the case and the result was satisfactory. There would have been no necessity for worry had the teeth been removed before irradiation. For this reason we believe that it is safer to sacrifice *all* remaining teeth before therapy is started. Certainly the minimum that should be done is

to take those in the direct beam of radiation.

Tooth sockets are not the sole means of entry of infection into bone damaged by irradiation (Cases I, II, and V). In some instances heavy irradiation injures the overlying soft tissue so much that varying degrees of dissolution will occur and infection will enter the devitalized bone directly. Such a complication can hardly be avoided. It may be necessary to give heavy doses of radiation to control a tumor such as in Case I, or the patient's tissue tolerance may be poor. In such situations prevention can be directed only towards rigid post-therapy oral hygiene to obviate deep mucous membrane ulcerations which might eventually extend down to bone.

Very little has been written about the active treatment of osteoradionecrosis. Kanthak[2] states that sequestrectomy may be indicated when dead bone separates or when a pathological fracture appears. Swift[7] says that no attempt should be made to dislodge the sequestrum unless it can be removed with ease. Since the unhappy experience with Case III, our policy has been one of extreme conservatism without making any attempts whatever to remove the dead bone until it has become loose enough so that it can easily be lifted out with an instrument. We believe that premature surgical intervention may cause damage to periosteum and bone, devitalizing bone which might otherwise be saved if it had not been traumatized; and that in any event the amount of bone to be lost cannot be definitely determined until it has been demarcated and loosened by the infection.

Swift[7] speaks of an involucrum being laid down by periosteum and of the danger of destruction of viable periosteum if sequestrectomy is attempted before the sequestrum has become separated. In the usual type of osteomyelitis an involucrum is formed by the periosteum and is laid down around the infected bone so that when the sequestrum is removed rigid bone remains. Figure 5 illustrates such a process following acute osteomyelitis of the mandible. The same type of repair does *not* occur, however, in osteoradionecrosis. The intense external irradiation plus the scattered radiation due to the high mineral content of bone undoubtedly destroys periosteum whether in combination with infection and trauma or not so that it is incapable of new bone production. There was no roentgen evidence of involucrum in any of these reported cases. In Case V the sequestrum did

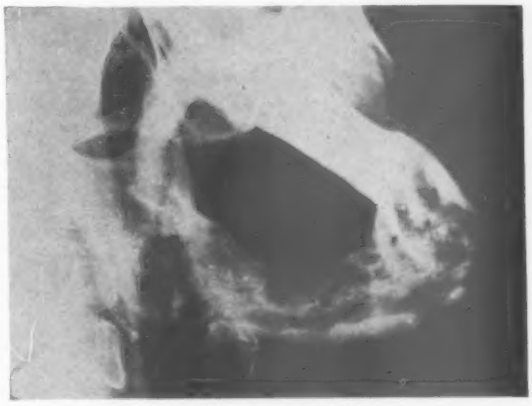

Fig. 5. Involucrum surrounding a sequestrum in acute osteomyelitis of the mandible.

not loosen sufficiently to be removed for three and one-half years after irradiation, and it consisted of the entire thickness of the mandible. Yet the patient has no deformity and the function of the mandible is normal. Undoubtedly a fibrous union did take place between viable bone to bridge the defect, but there is no calcification in it. Had the necrotic bone been removed before that union had become solid, the result probably would not have been as satisfactory. Case II had necrosis for three and one-half years without evidence of involucrum formation; Case VI for a shorter period. Undoubtedly the sequestrum serves a useful purpose in that it acts as a form or frame around which fibrous tissue is laid down, and when this function has been fulfilled it is slowly sloughed away. It should not be disturbed until its task is completed.

Soft tissue abscesses are not an infrequent complication. They occur adjacent to the diseased bone, but do not present a

serious surgical problem. They can be controlled by incision and drainage.

CONCLUSIONS

These six cases illustrate the three important factors in the production of osteoradionecrosis, namely, heavy irradiation, trauma, and infection. It can occur following heavy irradiation alone but is probably more common if associated with the other two factors. Ideally, all remaining teeth should be extracted before any radiation therapy is instituted. Minimally, the teeth in the direct beam of radiation should be removed and a period of at least ten days should ensue between the extraction and irradiation to permit healing in the tooth sockets.

Once osteoradionecrosis has occurred, the healing processes are unusually slow. The lesion should be handled with extreme conservatism with therapy directed towards keeping the involved area as clean as possible. Attempts should not be made to remove the sequestrum until it has become so loose that it can be lifted out with forceps. A bony involucrum such as is seen in association with acute osteomyelitis does not occur, and the sequestrum acts as a support around which fibrous union between normal bone occurs if the process involves the complete thickness of the mandible. Otherwise a permanent defect in the contour of the mandible may occur.

SUMMARY

1. Six cases of osteoradionecrosis are reported.

2. The importance of heavy irradiation, infection, and trauma in the pathogenesis of the complication is discussed.

3. A period of at least ten days should elapse between the time when teeth are extracted and radiation therapy started, to permit healing in the tooth sockets.

4. Therapy should be of the utmost conservatism until the sequestrum has become so loose that it can be removed easily without surgical intervention.

5. An involucrum in the ordinary meaning of the word probably does not form. On the other hand, there seems to be a fibrous union between normal bone.

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REFERENCES

1. WATSON, W. L., and SCARBOROUGH, J. E. Osteoradionecrosis in intraoral cancer. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *40*, 524–534.

2. KANTHAK, F. F. X-ray irradiation and osteonecrosis of the jaws. *J. Am. Dent. Ass.*, 1941, *28*, 1925–1929.

3. LAWRENCE, E. A., and BREZINA, P. Carcinoma of the oral cavity; ten year survey in a general hospital. *J. Am. M. Ass.*, to be published.

4. WARREN, S. Effects of radiation on normal tissues. XII. Effects on bone, cartilage and teeth. *Arch. Path.*, 1943, *35*, 323–340.

5. EWING, J. Radiation osteitis. *Acta radiol.*, 1926, *6*, 399–412.

6. DALAND, E. M. Surgical treatment of post-irradiation necrosis. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 287–301.

7. SWIFT, L. V. Osteomyelitis of the jaws. *J. Am. Dent. Ass.*, 1942, *29*, 1590–1600.

LEUKOSARCOMA*

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STERNBERG[12,13] in 1908 first called attention to a group of cases which have a marked mediastinal enlargement including the thymus gland and a terminal blood picture usually classified as an acute lymphatic leukemia. There are also enlarged superficial lymph glands in various parts of the body in most cases and when a biopsy is done on one of these glands it is usually reported as a lymphosarcoma. At autopsy in addition to a lymphoblastic infiltration of the thymus and other glands, there is an enlarged spleen and liver with lymphoblastic infiltration, enlarged kidneys with lymphoblastic infiltration and similar involvement of other organs. These cases appear to constitute a clinical entity.

Most reports of these cases have occurred in medical literature other than roentgenological publications. The thymic enlargement frequently produces the first symptoms which are severe enough for the patient to seek medical aid, and a chest roentgenogram will probably be among the first examinations done. The roentgenologist should, therefore, be familiar with the condition so that he can properly evaluate the roentgen findings.

To review the literature covering the pathological aspects and all the clinical features of these cases is beyond the scope of this presentation. A few facts of general interest to the radiologist will be reviewed. For a complete review of the literature the reader is referred to the bibliography, particularly in the articles by Margolis,[8,9] Isaacs,[7] and Friedlander and Foot.[4] Leukosarcoma may occur at any age. Isaacs[7] reviewed 15 cases of lymphosarcoma which had a leukemic blood picture. The ages varied between six and seventy years. Approximately one-third of the cases were between twenty-one and thirty years of age. A review of the cases reported in the literature did not show a preponderance of the disease in either sex.

In reviewing the literature it is apparent that all cases which are reported do not completely conform to Sternberg's description. Major,[10] Margolis,[8,9] Craver and MacComb,[1] Haagensen,[5] and Friedlander and Foot,[4] report cases which conform to Sternberg's description of leukosarcoma. Flashman and Leopold[3] reviewed 107 cases reported in the literature which they believe should be classified as leukosarcoma, but in only 60 of these cases was the primary site of invasion the thymic gland, and in many of them no thymic tumor was found at autopsy. These authors report a case where the primary gland involvement was apparently the retroperitoneal glands of the lower right quadrant with later involvement of other lymph nodes scattered throughout the body. At autopsy invasion of many vital organs was demonstrated but there was no thymic involvement. Evans and Leucutia[2] have expressed the opinion that if patients with lymphosarcoma lived longer more of them would probably have a terminal leukemic blood picture.

Isaacs[7] believes the condition is a primary blood dyscrasia and that the other changes which occur are secondary. Most descriptions of the leukemic blood picture which occurs in the terminal phase of the disease designate the predominant blood cell as a lymphoblast. Isaacs believes that the predominant blood cell can be differentiated from lymphoblasts and other immature blood cells by staining characteristics. He designates the cell as a leukosarcoma cell.

The symptoms of which the patient complains vary considerably and the blood picture may be normal when the patient is

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first seen. Symptoms reported by various authors include: malaise, weight loss (usually slight), slight elevation of temperature, bleeding (petechiae, hemoptysis, hematuria, epistaxis, hematemesis, gross bleeding from the mucous membranes and retinal hemorrhages), joint pains, chest pains, cough, dyspnea, herpes, toxic erythema multiforme, diplopia and local edema. In our second case the respiratory distress and the edema of the neck and face were marked.

Margolis,[8,9] Craver and MacComb,[1] and Friedlander and Foot[4] review the discussions in the literature regarding the origin of the invading cell in this group of cases. Sternberg[12,13] believed that the large lymphoblastic type of blood cell and its infiltration in the thymus and other vital organs was an essential part of picture in these cases. Many of the opinions predicate the thymus gland as the origin of the invading cell. Margolis,[8,9] and others, believed that the thymic gland is invaded along with the other organs and that the cells do not represent hyperplasia of the thymic gland cells.

The 2 cases which are reported conform to Sternberg's description as both had large thymic tumors. When one case was seen the first time he had a marked leukemia and was far advanced clinically. The other case was seen some time before he developed the leukemic blood picture and was relieved of his dyspnea by treating the mediastinal mass with roentgen irradiation.

Some of the early workers thought that roentgen therapy precipitated the leukemic phase of the syndrome. That this is not the case is a fact recognized by radiologists and by most others who have reported cases during recent years. One of the cases being reported never received any roentgen therapy and ran the same acute course with fatal termination as the case who did receive roentgen therapy.

Roentgen therapy is indicated when the mediastinal enlargement or other glandular masses are causing circulatory or respiratory distress. When the patient is seen before the leukemic phase of the disease and when there is a very large mediastinal mass producing embarrassment of respiration and blocking adequate circulation to the head and neck with gross swelling of the head and face, the response to roentgen therapy is prompt and dramatic. Gross reduction in the tumor mass with relief of the distress and edema within twenty-four to forty-eight hours after the administration of 200 r to 400 r should cause the radiologist to suspect that he is dealing with a leukosarcoma. Roentgen therapy does not influence the course of the disease which usually terminates fatally in a few weeks to a few months.

CASE REPORTS

CASE 1. The patient, male, white, aged twenty-seven, was admitted to Letterman General Hospital, March 23, 1944, by transfer from another hospital with a diagnosis of acute lymphatic leukemia. He gave a history of having an occasional blue spot appear in the subcutaneous tissue after slight trauma for a period of two years but his general health had always been good. The patient was inducted into the Army August 12, 1943, and maintained his good health during his period of basic training. Although he had never had frequent attacks of tonsillitis, he was subject to frequent upper respiratory infections and for this reason and because his tonsils were greatly hypertrophied, they were removed during the last week of January, 1944. A blood count made at the time of the tonsillectomy, January 27, 1944, showed a white blood cell count of 11,950 and hemoglobin of 90 per cent. No red blood cell count was done. The differential count was polymorphonuclear neutrophiles 75 per cent, lymphocytes 22 per cent, monocytes 3 per cent. The examination of the urine was negative. Following this operation, the patient bled for three days but not excessively. In the month immediately following the tonsillectomy, the patient complained some of weakness and sore throat but continued active military training.

On March 5, 1944, soon after starting on a hike, he had to fall out because of weakness and shortness of breath. His outfit was transferred to another station where they arrived March 12, 1944. The following day, he noticed

areas of discoloration beneath the skin which were at first pinpoint in size and later greatly increased. On the same day, while receiving a football which had been kicked by another soldier, he was accidentally struck across the eyes and immediately experienced severe hemorrhage in the soft tissues about the eyes. Because of the marked ecchymosis about the eyes and the pain associated with this condition, he was admitted to the station hospital on his post.

Examination revealed small but definitely enlarged lymph nodes in the axillae and in the supraclavicular areas. There was physical and roentgen evidence of marked widening of the superior mediastinum. The liver and spleen were palpable. On admission, the blood count showed 208,200 leukocytes, of which 93 per cent were agranulocytes. Of the 93 per cent agranulocytes, 69 per cent were classified as lymphocytes and 23 per cent as lymphoblasts. The red blood count was 3,510,000 and the platelet count, 130,000. A sternal puncture done March 16, 1944, showed an overwhelming increase in the number of agranular mononuclear leukocytes (lymphoid cells, lymphocytes and lymphoblasts) at the expense of normal granulocytic and erythroblastic bone marrow. All the megakaryocytes were in a state of regression. There was only an occasional nucleated red blood cell. The peroxidase stain revealed 99 per cent agranulocytes and 1 per cent granulocytes. The differential study of the bone marrow (Wright's stain) showed 38 per cent lymphocytes, 24 per cent lymphoblasts (including Rieder cells), an occasional eosinophilic myelocyte and an occasional neutrophilic myelocyte. The other cells were all highly undifferentiated, immature cells.

Fig. 1.* Case 1. Posteroanterior roentgenogram of the chest, March 23, 1944. There was a large mediastinal mass which measured 14.5 cm. in width at the level of the first interspace, anteriorly.

Examination of the eyes showed, in addition to the massive subcutaneous hemorrhage, severe hemorrhage and edema of the bulbar

* Reproduction of roentgenograms by the Letterman General Hospital Photographic Laboratory.

Table I

BLOOD COUNT ON CASE I

Date 1944	Red Blood Cell Count	White Blood Cell Count	Hemoglobin	Segmented Polymorphonuclears	Lymphocytes	Lymphoblasts	Other Premature Forms	Platelets
March 15	3,500,000	204,000	71%	3	69	23	5 (3 Rieder cells)	130,000
March 20	3,500,000	280,000	70 %	3	53	26	18 (14 Rieder cells)	
March 24	2,800,000	296,000	8.5 gm.				97 blasts	80,000
March 27	2,360,000	316,000	6.2 gm.	3			97 blasts	
March 28	2,570,000	408,000	8.5 gm.					
March 29	3,460,000	450,000	9.0 gm.					
March 30	2,890,000	433,000	8.0 gm.	3			97 blasts	
April 3	2,460,000	310,000	5.5 gm.	2			98 blasts	

subconjunctival tissue. There was one flame-shaped hemorrhage along the upper left temporal vessels of the left eye just above the macula. There was ecchymosis of the bulbar conjunctiva, severe on the right with edema and moderate on the left. The diagnosis made was acute lymphocytic leukemia.

When the patient was transferred to Letterman General Hospital he showed essentially the same findings. The blood count, however, showed 296,000 white blood cells, 2,800,000 red blood cells and 80,000 platelets; the differential count showed three polymorphonuclear cells, the remainder being very premature cells classed as blasts, probably lymphoblasts, and smudges.

Other blood findings were: negative Kahn reaction; negative heterophile antibodies; prothrombin time 21 seconds with control of 16 seconds; urea nitrogen 23 mg. per 100 cc.; total protein 5.8 mg. of which 4 mg. was albumin and 1.8 mg. was globulin; bleeding time 2 minutes and clotting time 7 minutes. The white blood cell count reached 433,000 six days before death and a few hours before death was 310,000. In the last count practically all the cells were blasts, apparently lymphoblasts. The urinalysis at this time was negative, including the Bence-Jones test. The chest roentgenogram showed a large mediastinal mass which could not be separated from the heart and aorta and which measured 14.5 cm. in width at the level of the first interspace anteriorly. The roentgenogram also showed moderate infiltration of the lung parenchyma at the right base. The patient's clinical course in the hospital was rapidly retrogressive with increasing weakness, signs of mediastinal compression, and abdominal distress, apparently due to the enlarged liver. Microscopical blood appeared in the urine March 28 and two days later there was gross bleeding from the kidneys which continued until death. The liver continued to enlarge and before death on April 4, 1944, it extended well below the umbilicus. During the final stage of the disease, the patient became orthopneic, suffered increased distress in the upper abdomen, was unable to eat because of nausea and vomiting and showed signs of moderately increased respiratory distress. Except for the mediastinal dullness and a few râles at the bases, no physical findings were elicited over the chest. Both the lower extremities became moderately edematous.

Autopsy Findings. A complete autopsy was done by Lt. Col. Harold L. Stewart, M.C. a few hours after death on April 4, 1944. The positive findings were as follows:

General: There were petechiae scattered over the entire body, most numerous over the chest anteriorly. There were also large purpuric patches measuring 10 cm. in diameter on both arms. Inspection of the mouth showed hemorrhage about the gum lines of the teeth and small petechiae of the mucosa of the mouth, tongue, and lips. The lymph nodes in the neck, the axillae and the inguinal regions were palpable and were small, discrete, shotty bodies. It is impossible to tell whether the conjunctiva was jaundiced or not owing to marked hemorrhage.

Chest: When the chest cavity was opened, a mediastinal mass was encountered which was tightly adherent to the sternum. The muscles overlying the anterior chest wall were also adherent to the sternum. Each pleural cavity contained approximately 1,100 cc. of brownish fluid; both lungs were collapsed and there were a few adhesions between the right lung and the mediastinum. The mediastinal mass measured 10 cm. in width and 19 cm. from top to bottom and appeared to completely replace the thymus gland. The lower portion of the mass was adherent to the diaphragm. The pericardial cavity contained approximately 350 cc. of deep cherry-colored blood and the visceral and parietal layers of the pericardium were covered by a thick fibrinous exudate. The heart, lungs and mediastinal tumor were removed in one mass. Examination of the mediastinal contents revealed that the esophagus was somewhat compressed by the mediastinal tumor but was apparently not infiltrated or encircled. There were numerous enlarged lymph nodes about the bronchi. Portions of these lymph nodes were hemorrhagic and part were gray in color. The aorta was completely encircled by the mediastinal mass and while it was somewhat constricted, it was not entirely closed off. Several of the other great vessels were also encircled and constricted. The trachea and bronchi passed posterior to the tumor and while pressed upon anteriorly, they were not constricted. In the right lung, there were numerous nodular areas on the pleural surface which dipped into the lung tissue for a short distance. These were all small, some of them the size of miliary tubercles and others larger and less sharply defined. In the upper lobe of the right lung, there was a

conical-shaped, infarcted-like area which was sharply circumscribed, red in color and surrounded by a slightly gray border. This area measured 3 by 1.5 cm. The right pulmonary aorta was somewhat constricted but the mediastinal mass and the right pulmonary vein less constricted. The left lung also showed nodular foci involving the pleura which were most numerous at the base. There were also focal patches of fibrinous exudate and petechial hemorrhage. The mediastinal tumor extended into the root of the left lung involving the pleura. The main branches of the pulmonary aorta were somewhat constricted where they passed from the mediastinum into the left lung.

Spleen: The spleen weighed 950 gm. and was greatly enlarged, the capsule was tense and dark red. The cut surface scraped fairly easily. No follicles were observed.

Lymph Nodes: The lymph nodes of the mesentery were all palpable and many of them were discrete and the largest measured approximately 3 cm. in length. The lymph nodes about the stomach and pancreas were enlarged and replaced by soft gray hemorrhagic tissue. Most of these were discrete and the largest measured about 3 cm. in diameter.

Bone Marrow: The bone marrow of the right femur formed a solid plug as thick as the finger completely filling the bone marrow cavity. A great deal of the bone marrow from this bone was dark red but parts were gray and yellowish. The bone marrow from the sternum was red.

Liver: The liver weighed 2,500 gm. The external surface was red and the capsule smooth. The cut surface had a brownish cast and the markings were indistinct.

Kidneys: Each kidney weighed 180 gm. and both capsules stripped easily leaving a smooth surface. The cortex and medulla were swollen but well differentiated. The kidney pelves showed excessive mucosal hemorrhage.

Testicles: There were numerous hemorrhages in the tunica and on the cut surface of the testicles.

Brain: Examination of the brain showed a hemorrhagic area 1.5 by 1 cm. below the cortex of the right lateral hemisphere at the lateral optic chiasm. The hemorrhagic area was above the nuclei and did not show any communication with the ventricle. Another hemorrhagic area was found in the posterior portion of the brain at the level which cut through the horn of the right ventricle. This hemorrhagic area measured 1 cm. in diameter. There were a few other small petechial hemorrhages in the occipital lobe.

The organs showed no significant gross changes.

Microscopic Examination.

Thymic tumor: Sections of the thymic tumor reveal that it was composed of small, irregular, loosely arranged nests of neoplastic cells inclosed by thin strands of adult stroma containing numerous small capillary vessels. No thymic tissue was identified. The neoplastic cells were small, deeply hyperchromatic and fairly regular in size and the cytoplasm was scanty. The nucleus tended to be rounded but the outline was often irregular and serrated. In many cells, the nucleus stained solidly. In others, the nucleus was more open but still contained numerous chromatin particles, one to three of which stood out in sharp relief. Mitotic figures were numerous and frequently atypical. There was sporadic cellular degeneration and necrosis and foci of hemorrhage but on the whole, the neoplastic tissue was surprisingly well preserved.

Bone marrow: Throughout the bone marrow, there was extensive hemorrhage. The majority of the cells were leukemic cells identical with those of a thymic tumor. All of the various types of bone marrow cells were identified but they were present only in minimal numbers having been almost completely crowded out by the pronounced leukemic infiltration.

Lymph nodes: The normal architecture of the glands had been destroyed by infiltration of the leukemic cells leaving only an occasional follicle.

Spleen: The follicles were small and scanty. The pulp was infiltrated and the sinusoids distended with leukemic cells. There were scattered small foci of myelopoiesis. It was impossible to definitely identify the cells as mature lymphocytes on the basis of stained preparations but the appearance of these cells appeared to be compatible with a lymphatic type of cell.

Heart: The small capillaries in the myocardium were distended with leukemic cells. The individual myocardial cells were pale and lumpy. There was a pronounced leukemic infiltration on the pericardial surface of the heart and this was in turn covered by a shaggy, fibrinous exudate.

Lungs: Sections of the larger bronchi showed leukemic infiltration in the submucosa and the surrounding connective tissue. Sections of the lung revealed pronounced leukemic infiltration

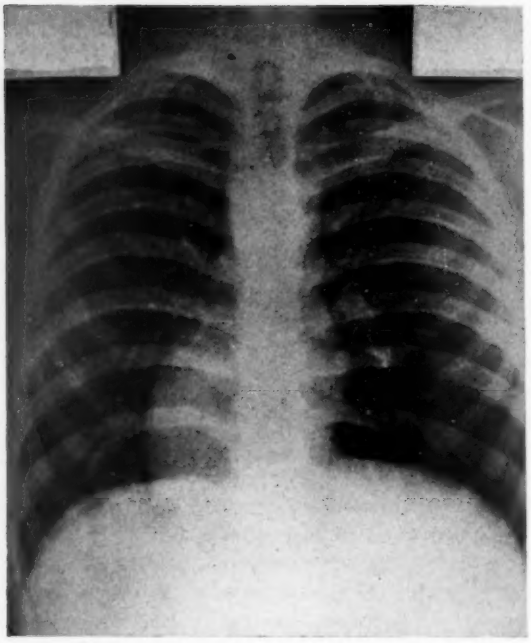

Fig. 2. Case II. Posteroanterior roentgenogram taken at time of induction into the Army August 7, 1944. No abnormal mediastinal shadows were demonstrable.

of the pleura, the cells being arranged in a sheet-like membrane over the surface of the lung. Many small capillaries were distended with leukemic cells. The larger interstitial septa were thickened and edematous and showed considerable leukemic cell infiltration. The area of infarction which was described in the gross findings showed considerable fibrous tissue deposits which would indicate that they were not terminal in origin.

Intestinal tract: In the intestinal tract, there was infiltration of leukemic cells in the lymph follicles of the intestine and a few petechiae in the stomach.

Liver: There was moderate leukemic infiltration in the portal area of the liver and the sinusoids were distended with leukemic cells.

Kidneys: There was pronounced mucosal hemorrhage of the pelves. In the wall of the pelves and in the surrounding tissues, there was leukemic infiltration. A number of the renal tubules were dilated and the lining cell appeared to be of the low cuboidal type.

Testicles: The testicles showed fairly large leukemic infiltration of the interstitial tissue associated with some necrosis and degeneration of the tubules. There was also some hemorrhage.

Brain: The sections of the brain in the areas where gross hemorrhagic changes were noted confirmed the presence of a hemorrhage and also showed an infiltration of leukemic cells. Sections from other portions of the brain showed numerous microscopic areas of hemorrhage and leukemic infiltration.

Skin: Sections through the skin at the site of several petechial hemorrhages showed infiltration of the blood cells and leukemic cells in the subcutaneous tissues.

The other organs showed no significant changes.

Case II. The patient, male, Mexican, aged eighteen, was admitted to Letterman General Hospital, November 17, 1944, because of shortness of breath and weakness. The patient gave a history of being under supervision as a cardiac patient at a civilian hospital for six years before his induction into the Army on October 6, 1944. During these six years he was reported to have had slightly enlarged cervical lymph nodes and an apical systolic heart murmur. During this six year period he received no special treatment and was kept under observation and his activities were restricted. His induction roentgenogram of the chest was reported normal and after his physical examination at the time of his induction he was assigned to an infantry training battalion. When he attempted to engage in basic training such as hikes and grenade practice, it became apparent to his squad leader that he was unable to participate because of weakness and shortness of breath. He was examined at the dispensary at the direction of his commanding officer and was hospitalized at the station hospital of his camp on October 30, 1944. At this time roentgen examination of the chest revealed a large mediastinal mass and there were palpable glands in the right and left cervical areas associated with considerable edema of the neck and face. A biopsy was done on one of the cervical nodes and the patient transferred to Letterman General Hospital.

Examination at Letterman General Hospital confirmed the presence of the large mediastinal mass. Other findings were as follows: Head: Eyes—pupils equal, regular, react to light and accommodation. Examination of the eye grounds showed normal discs, vessels thin, pale and not tortuous. Hearing normal. No nasal obstruction. Tongue clean. Pharynx normal.

Tonsils out. Neck: Universally enlarged and full. The jugular veins were prominent but there were no unusual pulsations. There were palpable masses in the right and left anterior cervical areas. These masses varied in diameter from 2 to 5 cm., were smooth and soft and were apparently fixed to the underlying structures. Thorax: Except for the parasternal dullness associated with the mediastinal mass the lungs showed no abnormal physical signs. The apex beat of the heart was not visible; there was no palpable thrill or shock and the rate and rhythm was normal. The left border of the heart extended beyond the mid-clavicular line. There was a systolic murmur at the apex transmitted to the left axilla. Abdomen: There was a scaphoid type of abdomen. The spleen and liver were not palpable and no masses could be demonstrated. Other systems: Examination of the genitourinary tract, the anus and rectum, the bones and joints, the muscular system and the nervous system did not demonstrate any abnormalities. Except for the enlarged cervical glands no superficial nodes were found to be enlarged. The white blood cell count at this time was 8,450, the red blood cell count 3,870,000 and the hemoglobin 12 grams. The differential count showed 64 per cent segmented polymorphonuclears, 5 per cent stabs, 2 per cent basophiles, 3 per cent eosinphiles, 21 per cent lymphocytes and 5 per cent monocytes. The Kahn test was negative and the urinalysis was normal. The microscopical diagnosis on the biopsy of a cervical node was lymphosarcoma.

Between November 21 and 30, 1944, roentgen therapy was given to each of two 15 by 15 fields, which covered the superior mediastinum and the lower half of the cervical areas. One field was treated daily, alternate fields being used. In this way only half of the mediastinum was treated each day. Each field received a total of 1,000 r. Improvement which followed the roentgen therapy was dramatic. After the first forty-eight hours, during which 200 r was administered to each field, the edema in his neck and face was greatly reduced. A roentgenogram made November 27, 1944, after each of two fields had received 600 r, showed almost complete disappearance of the mediastinal tumor and the edema in the face and neck had entirely disappeared. The cervical nodes were by this time barely palpable. Chest roentgenograms made December 11 and 16, 1944, showed no masses and the mediastinal shadows were thought to be within normal limits.

On November 18, 1944, the leukocyte count was 8,500 and the differential count was normal with 64 per cent segmented polymorphonu-

TABLE II

BLOOD COUNT ON CASE II

Date 1944	Red Blood Cell Count	White Blood Cell Count	Hemoglobin gm.	Segmented Polymorphonuclears	Stabs	Juveniles	Myelocytes	Eosinophiles	Basophiles	Lymphocytes	Lymphoblasts	Other Premature Forms	Monocytes	Platelets
Nov. 18	3,870,000	8,500	12.0	64	5			3	2	21			5	
Nov. 22	4,580,000	18,700	13.5	74	7			2	4	9			4	
Nov. 23	4,310,000	13,950	14.5	84	3					11			2	
Nov. 27	4,020,000	4,500	13.0	62	10		1	3		20			4	
Nov. 28	3,940,000	7,200	11.5	76	4			3		13			4	
Nov. 30	4,030,000	7,100	12.5	52	5		1	3		33			6	
Dec. 1	3,860,000	6,500	11.5	58				5		30			7	
Dec. 4	4,100,000	19,500	12.5	37	24	1				32			6	
Dec. 5	4,160,000	19,700	12.0	15	25	8	4			44 (12 immature)			1	
Dec. 6	4,060,000	19,700	12.5	18	16	6	4	1		54	1			
Dec. 7	4,040,000	25,600	12.0	15	10	4	1	1	1	5	13	48	2	
Dec. 15	3,900,000	19,500	10.0	1	6			1		2		86	4	
Dec. 20	960,000	9,000	3.0	1	1			1		1		96		

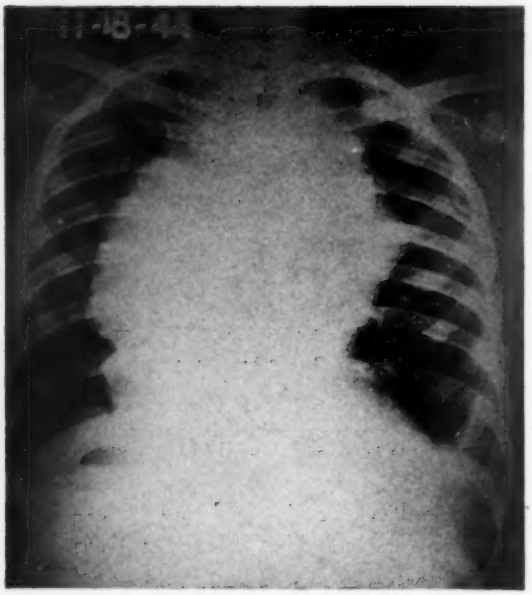

Fig. 3. Case II. Posteroanterior roentgenogram of the chest, November 18, 1944. At this time, the patient was having marked respiratory distress and there was marked edema of the neck and face.

clears, 5 per cent stabs, 2 per cent basophiles, 3 per cent eosinophiles, 5 per cent monocytes, and 21 per cent lymphocytes. On November 22, 1944, the leukocyte count was 18,700 but the differential count remained normal. On November 23, 1944, the leukocyte count was 13,950 and there were 84 per cent segmented polymorphonuclears, 3 per cent stabs, 2 per cent monocytes and 11 per cent lymphocytes. On these two days there was slight elevation of temperature, the highest recorded temperature being 101° F. The blood count then returned to normal, being 4,500 on November 27, 1944. The leukocyte count on December 1, 1944, was 6,500. On December 4, 1944, the leukocyte count was 19,500 but the differential count was normal. The leukocyte count continued to range between 19,000 and 24,000 until December 17, 1944, with a gradual change in the differential count. A differential count made December 15, 1944, showed 1 per cent segmented polymorphonuclears, 6 per cent stabs, 1 per cent eosinphiles, 2 per cent lymphocytes, 4 per cent monocytes and 86 per cent premature undifferentiated cells. These premature cells were described as having ameboid movements similar to lymphoid cells and only an occasional nucleolus could be demonstrated. There was no perinuclear clear zone and the cytoplasm was deep blue. It was suggested by the hematologist that these might be leukosarcoma cells as described by Isaacs or they might be lymphoblasts. At this time the total proteins were reported as 5.2 mg. (albumin 2.6 mg. and globulin 2.6 mg.). About the time that the patient's leukocyte count began to increase he became more acutely ill and both the spleen and the liver became palpable. From December 17, 1944, until the patient's death on December 21, 1944, the leukocyte count gradually fell and twenty-four hours before death was 9,000c. During the last three weeks of the patient's life the red blood cell count gradually decreased and twenty-four hours before death he had 960,000 red cells and a hemoglobin of 3 grams. After the mediastinal mass became reduced in size following roentgen therapy, it did not recur and the patient suffered no further respiratory distress.

Autopsy Findings. Complete autopsy was done by 1st Lt. John B. Frerichs, M.C., a few hours after death December 21, 1944. The positive findings were as follows:

General: In the right supraclavicular space there was a well healed incised scar 2.5 cm. long. The skin of the upper chest anteriorly showed many brown, apparently scarred areas. There was a bruise around the right eye. Scattered petechiae were visible in the skin and these were by far more numerous over the lower legs than anywhere else.

Chest: When the chest was opened some extravasations of blood were seen in the thoracic muscles. The left pleural cavity contained 350 cc. of bloody fluid. The right pleural cavity contained 1,100 cc. of similar fluid. The pericardial cavity contained the normal amount of fluid, which was not bloody. There were huge numbers of scattered and sometimes confluent petechial hemorrhages beneath the visceral pericardium. The entire ventral mediastinum was occupied by a flat mass of pale grayish-tan tissue. The weight of this mass of tissue with some shreds of adherent tissue was 150 gm. The superior part of the mass was thymus and was approximately normal in size and shape, although on section thymic lobulations were not visible with normal clarity and hardly any fat was present. The inferior part of the mass preserved the same roughly lobulated shape of the thymus but reached down to cover the entire ventral parietal pericardium and extended out slightly to the sides from here. This was all that

was left of the huge mediastinal tumor which caused the patient's presenting complaints. At autopsy, this mass did not obstruct the trachea or blood vessels.

The pleura was smooth and transparent. The hilar lymph nodes were enlarged. The lower lobe of the right lung showed moderate atelectasis. The lungs showed no other gross changes. The myocardium showed numerous hemorrhagic areas both in the right and left ventricles but there were no other noteworthy changes. Some of the branches of the great vessels were surrounded by the remains of the tumor mass but there was no compression of any of these vessels.

Abdomen: The abdominal cavity contained a small amount of free fluid but no adhesions. The peritoneum was smooth and transparent and hemorrhagic areas were visible in the retroperitoneal tissue.

Spleen: The spleen was moderately enlarged and weighed 300 gm. The shape of the organ was normal and the capsule was smooth and free from adhesions. Throughout the capsule there were visible numerous reddish colored firm areas which varied in size from 0.2 to 0.8 cm. in diameter. On section, the spleen was pale reddish-tan in color. Malpighian bodies were not visible with normal prominence. There were numerous small hemorrhagic areas scattered throughout the spleen and many tiny faintly brownish areas in the substance of the spleen.

Lymph nodes: Lymph nodes in the axillae, groins, neck, thorax and abdomen were enlarged. They varied in diameter from 1 to 5 cm. None of the lymph nodes showed normal architecture. They appeared to be made up of a pale grayish-tan and rather homogeneous looking tissue.

Bone Marrow: The bone marrow was inspected in many different vertebrae, many ribs and in the sternum. It appeared red in color but was somewhat paler than normal. In the femur no fat was found but rather a grayish and reddish marrow.

Stomach: There were numerous petechiae in the mucosa of the stomach. The gastric mucosa seemed to be unbroken. No other significant changes in the stomach were seen.

Intestines: The intestines were dark in color. Occasional petechiae were found which involved the mucosa and serosa. Three feet above the ileocecal valve, a Meckel's diverticulum was found. The diverticulum measured 7 cm. long and 3 cm. in diameter and was roughly

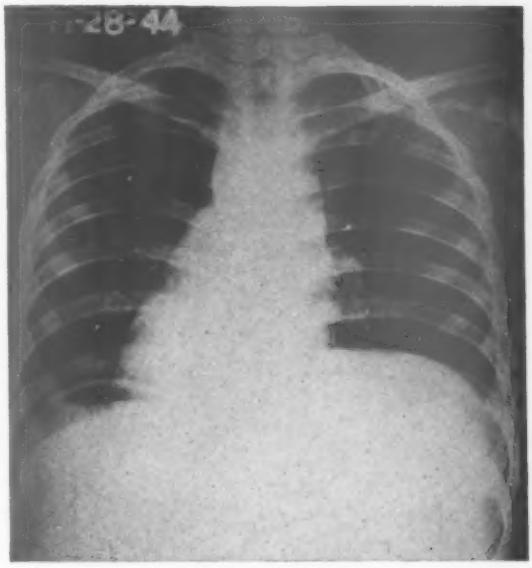

Fig. 4. Case 11. Posteroanterior roentgenogram of the chest, November 28, 1944. In the preceding seven days, the patient had received 600 r to the mediastinum. The mediastinal mass has almost completely disappeared as well as the small amount of infiltration at the bases.

cylindrical in shape. Near the blind end another small diverticulum arose from the main one. This second diverticulum was roughly round and was attached to the main diverticulum by a thin stalk and was only 0.2 to 0.3 cm. in diameter. Except for a few petechiae, the colon was negative.

Liver: The liver was definitely enlarged, weighing 2,035 gm.; its shape was normal. The capsule was delicate and transparent. On section, hepatic lobulations were easily visible and were uninterrupted anywhere in the liver. The periportal spaces were all moderately and diffusely thickened and presented a hyalin gray appearance. The central parts of the liver lobules were a light tan in color.

Kidneys: The kidneys were normal in size and shape. The only abnormal aspect was a hemorrhagic nodule of tissue 2 cm. in diameter in the upper pole of the left kidney. The capsule stripped with moderate difficulty and the surface was smooth, although little reddish elevations above it were visible from place to place. On section, normal renal markings were visible in most places but there were many grayish, indefinitely outlined zones within which the renal striae could not be seen. The cortical and

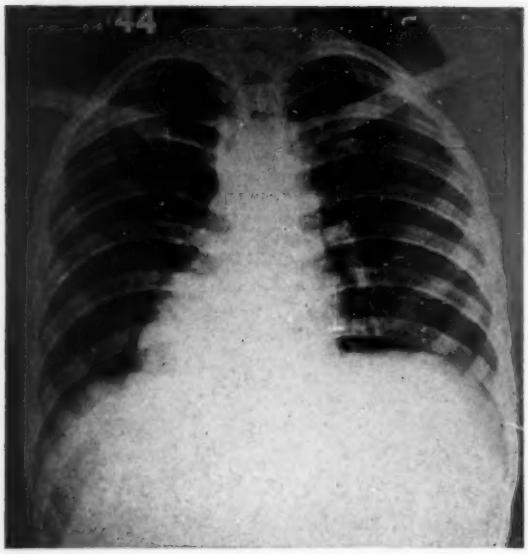

FIG. 5. Case II. Posteroanterior roentgenogram of the chest, December 11, 1944. This remains essentially normal although the patient was at this time growing progressively weaker as the blood dyscrasia progressed.

medullary proportions were about normal. The renal pelvis was empty and normal in size, but there was rather diffuse submucosal pelvic hemorrhage.

Other organs: The other organs, including the central nervous system, the adrenals, the thyroid, the testes, the prostate and the bones, did not show any significant changes.

Microscopic Examination.

Thymic tumor: Sections showed many small lymphocytes with deeply basophilic dense nuclei and scanty cytoplasm and an approximately equal number of large cells with more cytoplasm. In some of the larger cells, a nucleolus was present and mitotic figures were not infrequent.

Bone marrow: Bone marrow from the sternum, ribs, vertebrae and femur showed a very cellular narrow structure in which the great majority of the cells were lymphoid. Some of the cells were definitely megakaryocytes, more or less pyknotic.

Spleen: There were several areas of infarction where the structures stained poorly and which contained an infiltration of red blood cells and precipitated protein. Several fields showed an extravasation of leukocytes through small blood vessel walls. Some of the sinusoids were packed with large mononuclear-like cells which were hyperchromatic and deeply basophilic. It could not be determined whether these cells were lymphoblasts or some other type of premature leukocytes.

Lymph nodes: The normal architecture of the glands was destroyed and cells similar to those found in the spleen were infiltrated throughout the glands.

Heart: There was an infiltration of lymphoblasts throughout the myocardium and in some portions of the epicardium. The myocardium also contained scattered petechiae.

Lungs: There were scattered areas of atelectasis in the right lung and numerous areas of lymphoblastic infiltration throughout both lungs and in the pleura.

Intestinal tract: There were numerous patches of stomach and intestine wall which showed infiltration with lymphoblasts and others in which red blood cells were infiltrated.

Liver: The liver showed extensive lymphatic leukemic infiltrations best seen around the periportal spaces. There was also marked central lobular atrophy and some necrosis.

Kidneys: The nodule in the upper pole of the left kidney consisted of extravasation of many lymphoblasts and red blood cells and a few monocytes and polymorphonuclear cells. Petechial hemorrhages and small areas of lymphoblastic infiltration were scattered throughout both kidneys. The tubules contained much precipitated protein.

Skin: The heavily pigmented areas on the chest showed an infiltration of lymphoblasts and red blood cells in the subcutaneous tissue.

Other organs: Other organs, including the central nervous system, the adrenals, the thyroid, the testes, the prostate and the bones did not show any significant changes.

SUMMARY

Cases which conform to Sternberg's description and which have been designated as leukosarcoma constitute a clinical entity. Early in the course of the disease they have palpable lymph nodes, may show petechiae and soon develop a mediastinal tumor which involves the thymus. This mediastinal mass frequently causes respiratory distress and produces edema of the face and neck by blocking the return flow of blood and lymph. A biopsy on one of the lymph glands is usually diagnosed as lympho-

sarcoma. The disease runs a rapid course and in the terminal phase the blood picture changes from normal to that of an acute lymphatic leukemia. The disease terminates fatally in a few weeks to a few months.

The shortness of breath resulting from the mediastinal mass may be one of the symptoms which leads the patient to consult a doctor and the radiologist may have an opportunity of suggesting the clinical diagnosis before the blood changes occur. If the mediastinal mass recedes rapidly or almost disappears after roentgen treatment with a few hundred roentgens the diagnosis of leukosarcoma is likely.

Some reports in the literature would suggest that a similar syndrome may occur in which groups of glands other than those in the mediastinum may be primarily involved.

Some of the early writers on this subject thought that there was a primary tumor of the thymus in these cases but the work of Margolis,[8,9] and of others, would indicate that the thymus gland is infiltrated with the lymphoblastic cells as are other organs.

Two cases are reported which conform to Sternberg's description.

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REFERENCES

1. Craver, L. F., and MacComb, W. S. Lymphatic leukemia with thymic enlargement; brief review of the literature with case reports. *Am. J. Cancer*, 1932, *16*, 277–289.
2. Evans, W. A., and Leucutia, T. Neoplastic nature of lymphatic leucemia and its relation to lymphosarcoma. Am. J. Roentgenol. & Rad. Therapy, 1926, *15*, 497–513.
3. Flashman, D. H., and Leopold, S S. Leukosarcoma. *Am. J. M. Sc.*, 1929, *177*, 651–663.
4. Friedlander, A., and Foot, N. C. Malignant small-celled thymoma with acute lymphoid leukemia. *Am. J. M. Sc.*, 1925, *169*, 161–176.
5. Haagensen, C. D. Differential diagnosis of primary neoplasms of the mediastinum. *Am. J. Cancer*, 1932, *16*, 723–782.
6. Hellwig, C. A. Malignant thymoma. *Surg., Gynec. & Obst.*, 1941, *73*, 851–863.
7. Isaacs, R. Lymphosarcoma cell leukemia. *Ann. Int. Med.*, 1937, *11*, 657–662.
8. Margolis, H. M. Thymus gland in lymphatic leukemia. *Arch. Path.*, 1930, *9*, 1015–1026.
9. Margolis, H. M. Tumors of the thymus. *Am. J. Cancer* (supp.), 1931, *15*, 2106–2142.
10. Major, R. H. Thymus tumor associated with acute lymphatic leukemia. *Johns Hopkins Hosp. Bull.*, 1918, *29*, 206–208.
11. Milne, L. S. Unusual case of leukemia. *J. Am. M. Ass.*, 1913, *60*, 822–824.
12. Sternberg, C. Leukosarcomatosis. *Wien. klin. Wchnschr.*, 1908, *21*, 475–480.
13. Sternberg, C. Leukosarcomatosis and megaloblastic leukemia. *Beitr. z. path. Anat. u. z. allg. Path.*, 1916, *61*, 75–100.

ROENTGEN THERAPY FOR MALIGNANT TERATOMA OF THE TESTIS*

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WE REGARD it as a mistake to apply the term "teratoma" indiscriminately to all tumors of the testis, because teratoma of the testis is a specific pathologic entity. It is a tridermic tumor, one or more of whose components may undergo a malignant change. We also think that much of the confusion in the literature about this tumor is due to the fact that the authors were not writing about the same entity but were confusing testicular tumors in general with this lesion. Some authors believe that all the common tumors of the testis are fundamentally teratomatous in origin and therefore group them under the term "teratoma." Others feel that seminoma, at least, is a different and distinct entity and prefer to use the term "teratoma" to designate tumors which contain tissues derived from more than one germ layer. Furthermore, there is a tendency, when computing survival rates, to group all varieties of tumors of the testis together; consequently, it is impossible to determine to what extent irradiation has been of value in each or any variety of tumor from a review of the literature.

INCIDENCE

In 14.8 per cent of 142 cases of tumor of the testis reported by Cabot and Berkson,[1] the tumor was a malignant teratoma. If one accepts the estimate that 1 of every 1,500 consecutive males who are admitted to a hospital will have a tumor of the testis, it is evident that 1 of every 10,000 males who are admitted to a hospital will have a malignant teratoma of the testis.

MATERIAL

This paper is based on 54 cases of malignant teratoma of the testis that have been observed at the Mayo Clinic. In all of these cases, the diagnosis was made by histopathologic examination of a specimen of the tumor by Dr. A. C. Broders of the Section on Surgical Pathology. In 17 of the 54 cases, the patients had received treatment for the tumor before they came to the Clinic. In most of the 17 cases, the involved testis had been removed. We wish to emphasize that in all of the 17 cases specimens of the original tumor were examined by Dr. Broders. An aspiration biopsy was not performed in any case in this series. The surgeons who operated on the patients believe that orchectomy should be performed in every case in which there is a strong suspicion that the patient has a tumor of the testis.

ETIOLOGY

Few positive statements can be made about the cause of malignant teratomas of the testis. Since these tumors usually develop during the period of greatest sexual potency, it has been thought that there possibly is some relation between sexual function and the development of the tumor. A history of trauma can be obtained in from 10 to 30 per cent of cases of teratoma but it is doubtful whether trauma has any etiologic significance. It does, however, serve to call attention to a pre-existing malignant lesion. It also is reasonable to assume that severe trauma may be a factor in the dis-

* Abridgment of thesis submitted by one of us (R.J.S.) to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Radiology.

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semination of malignant cells. Likewise, antecedent infection, such as gonorrhea, syphilis, mumps and epididymitis, does not seem to be an important etiologic factor.

It is generally accepted that cryptorchism tends to favor the development of malignant tumors of the testis. In all of the cases in this series, the involved testis was situated in the scrotum. In 1 of the cases, however, the tumor developed nine years after orchidopexy had been performed. In cases of teratoma, the etiologic role of cryptorchism is less significant than it is in cases of seminoma.

Figure 1 is a graphic representation of

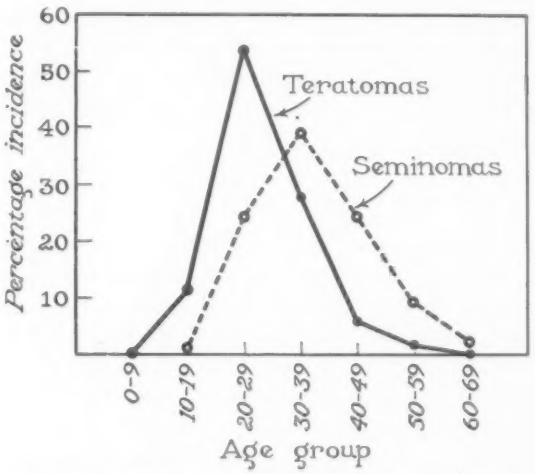

Fig. 1. Incidence of teratoma and seminoma according to age of patients.

the ages of the patients in this series of cases of teratoma and in a group of 103 cases of seminoma reported by Nash and one of us (E. T. L.).[7] It will be observed that the maximal incidence of teratoma occurs earlier in life than does the maximal incidence of seminoma. In the series of 54 cases of teratoma, the youngest patient was fifteen years of age and the oldest patient was fifty-nine years. In more than half of the cases (54 per cent) the patients were in the third decade of life and in 50 cases (93 per cent) the patients were between fifteen and thirty-nine years of age.

PATHOLOGY

Broders divided tumors of the seminal

Fig. 2. Adenocarcinoma of the seminoma type.

epithelium into three main groups: (1) teratomas, (2) adenocarcinomas of the semi-

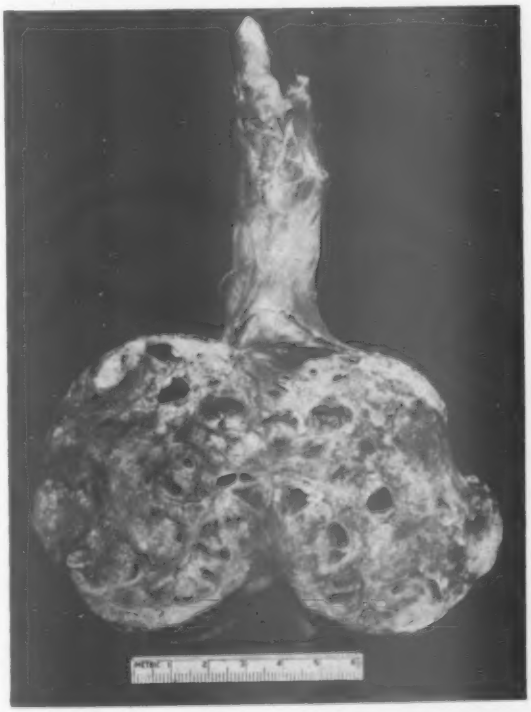

Fig. 3. Gross appearance of a malignant teratoma of the testis. This tumor contains both cystic and solid regions.

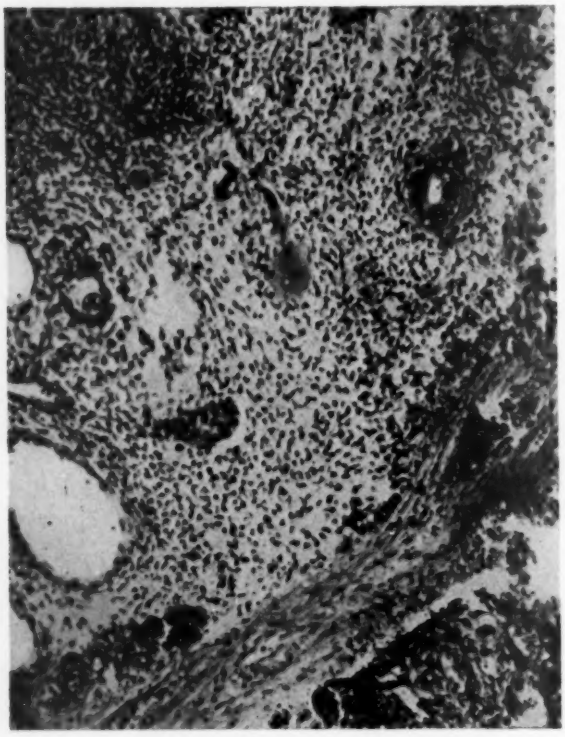

FIG. 4. Adenocarcinoma in teratoma of testis (×95).

noma type (Fig. 2) and (3) adenocarcinomas of the testis. The teratomas were subdivided into two subgroups: benign teratomas and malignant teratomas (Fig. 3 and 4). The tumors which comprise these three main groups display characteristic pathologic features which warrant their classification in separate groups. Whether these tumors originate from the same source or from different sources is not particularly important as far as the usefulness of this classification is concerned. We feel that this classification is sufficiently inclusive to embrace all common varieties of malignant epithelial tumors of the testis. Further subdivision would seem to be superfluous, unnecessary and, in most cases, impossible.

A teratoma is a composite mass of cells derived from more than one germinal layer, and in many instances it includes cells from all three layers. Many pathologists have held that it is not a tumor in the strict sense of the word but rather an abortive attempt at the formation of another individual. Teratomas may occur not only in the testis but also in the ovary, the roof of the mouth, the sacrum, the brain, the orbit, the mediastinum and, in fact in almost any tissue in the body. Nothing is known about how teratomas originate but the two most likely sources of malignant teratomas of the testis are totipotent sex cells, varying in age from primitive sex cells to nearly adult sex cells, and dislocated somatic blastomeres. These tumors usually arise in the rete testis but some probably arise in the tunica albuginea.

A malignant teratoma may be very small and be situated in the substance of the testis or it may be the size of a large grapefruit. Grossly, malignant teratomas are yellowish white and contain regions of necrosis and hemorrhage. Tortuous veins usually are visible on the surface. Until late in the course of the disease, the shape of the testis usually is about normal and the tunica is seldom invaded. Any remaining testicular tissue is frequently stretched out over the tumor tissue into a thin band. On cut section, the growth consists of alternate cystic and solid regions (Fig. 3).

Microscopically, the outstanding characteristic of this tumor is the varied appearance of its different portions. While in some sections one malignant tissue may have replaced or overgrown other tissues, if enough sections are studied one can usually identify structures from all the germ layers. In general, the tumor consists of embryonal structures arranged in such confusion as to eliminate any resemblance to an embryo. From the ectoderm one may find islands of squamous epithelium, neuroepithelial tissue, enamel organs, teeth, and cysts lined with squamous epithelium. By far the greatest amount of the tumor tissue originates from the meosderm. It is represented by cellular connective tissue, fibromyxomatous tissue, osteoid tissue, smooth muscle and embryonal cartilage. The last-named-tissue is particularly common. Arising from the entoderm one may find glands

lined with columnar epithelium, some of which may contain goblet cells. Some cysts are lined with columnar and cuboid epithelium while others may be filled with a colloidal material which resembles that found in a goiter. Although it is possible for any type of tissue to undergo a malignant change, by far the greatest incidence of neoplastic change is in tissue derived from the hypoblastic layer.

Table 1 shows the type of malignant lesion that was present in this group of cases. It might be mentioned in passing that in 5 cases the tumor was classified merely as a malignant teratoma. In these cases the available material was not sufficient to enable Dr. Broders to make a more specific histopathologic diagnosis, but malignant teratomatous elements were definitely present.

A malignant teratoma of the testis probably metastasizes in the same manner as a seminoma. The metastasis of seminomas of the testis has been described in detail by Nash and one of us (E.T.L.). Metastasis may occur by one or more of the following routes: (1) by the lympatics of the spermatic cord, (2) by the lymphatics of the scrotum and (3) by the veins. The most frequent sites of the metastatic lesions are as follows: (1) para-aortic lymph nodes, (2) supraclavicular lymph nodes, (3) peribronchial lymph nodes, (4) inguinal lymph nodes and (5) bone. Metastasis tends to occur soon after the tumor undergoes a malignant change. In cases of malignant teratoma, metastatic involvement of the peribronchial lymph nodes occurs more frequently and possibly earlier than it does in cases of seminoma.

The histopathologic appearance of the metastatic lesions is similar to that of the most malignant portion of the primary tumor but it is not uncommon for the metastatic lesions to have several of the characteristic features of the primary tumor.

SITE OF TUMOR

In this series of 54 cases, the site of the tumor was as follows: the right testis in 28 cases and the left testis in 26 cases. No instance of bilateral tumor was encountered in this series of cases.

SYMPTOMS

A painless swelling of the testis was the initial symptom in 68 per cent of the 54 cases. In many cases, it was impossible to ascertain how long the swelling had been present. Many of the patients said that the swelling had developed from a few days to a few years after the testis had been injured. One patient said that the involved testis always had been abnormally large. Some patients said that the enlargement had ceased temporarily and that the size of the testis had remained stationary for a long time but that it subsequently had increased rapidly.

The tumor may be very small and be buried in the substance of the testis; on the other hand, the involved testis may be as large as a fetal head. In 13 of the 37 cases in which the tumor had not been treated previously, the involved testis was the size of an orange when the patients were examined at the Clinic, and in 11 cases it was enlarged slightly. In this era of cancer consciousness, it seems incredible that a patient would allow a testis to become as large as a grapefruit before he consulted a physician, but this did happen in 6 of the 37 cases.

TABLE I

TYPE OF MALIGNANT LESION IN TERATOMA

Type of Lesion	Cases
Adenocarcinoma	42
Adenocarcinoma and sarcoma	2
Adenocarcinoma and epithelioma	1
Sarcoma	3
Adenocarcinoma and fibromyxosarcoma in teratoma and seminoma	1
Not specified	5*
Total	54

* Available specimen was not large enough to permit a more definite diagnosis but there was definite evidence of a malignant change.

In this series of 54 cases, it was difficult to determine how long the symptoms had been present. Some huge tumors were alleged to have been present for only a few weeks while some tiny ones were said to have been present for several years. In 1 case in which the involved testis was as large as an orange, the patient came to the Clinic because of "arthritis" and he was not at all concerned about the mass in his scrotum; in fact, he could not state accurately how long it had been present. We are convinced that there is no relation between the size of the involved testis and the duration of symptoms as stated by the patient.

TABLE II

SITE OF METASTATIC LESIONS IN SEVENTEEN CASES OF MALIGNANT TERATOMA OF THE TESTIS

Site of Metastasis	Cases
Para-aortic lymph nodes	13
Supraclavicular lymph nodes	7
Peribronchial lymph nodes	6
Inguinal lymph nodes	5
Bone	1

In 7 cases the initial symptoms were referable to metastatic lesions. This would seem to indicate that malignant teratomas tend to metastasize early, often before the patient is aware that the testis is the seat of serious trouble. This is one of the features that has led to the discouraging outlook in cases of teratoma of the testis.

Painful testis was the only symptom in 3 cases; in 5 other cases, pain was associated with swelling of the testis. In 8 additional cases, the patients complained of painful testis when they sought medical advice; therefore, testicular pain was a prominent symptom in 16 cases. Pain occurs more frequently in cases of malignant teratoma than it does in cases of seminoma.

Many other symptoms were present by the time the patients consulted a physician. One of the commonest symptoms was dragging pain in the groin on the involved side, and this often was accompanied by pain in the lower part of the back. In many instances, this pain was due to the increased weight of the diseased testis.

In 17 of the 37 cases in which the tumor had not been treated previously, there was clinical evidence of metastasis when the patients were examined at the Clinic. The site of the metastatic lesions in these cases is shown in Table II. Multiple metastatic lesions were present in several cases.

The symptoms of metastatic involvement of the para-aortic lymph nodes have been ably described by Desjardins[4] and have been considered by Nash and one of us (E.T.L). Involvement of these lymph nodes frequently produces a dull aching pain in the back, which often is called "lumbago" by the patient. The pain may extend into the hip or leg and is thought to be due to sciatica. Bloating, belching, fullness in the abomen after meals and constipation commonly are encountered after the para-aortic nodes have become involved. When the epigastric nodes are the seat of secondary deposits, symptoms referable to the abdominal viscera may occur so suddenly as to simulate an acute surgical disease.

Desjardins has pointed out that, although it is sometimes difficult to be certain of metastatic involvement of the para-aortic lymph nodes, in many cases a diagnosis can be made on the basis of history and the physical signs. When a definite mass cannot be palpated, only deep abdominal resistance may be found and pressure by the examiner's hand on this vague resistance frequently elicits tenderness which is not found when similar pressure is made on a normal abdomen. When the metastatic tumor has become sufficiently large, it may easily be palpated as a smooth or irregular, firm, immobile mass, most often lying on the side of the abdomen corresponding to the diseased testis, or lying toward the midline in the epigastric region. In certain cases, roentgenography and urography also may give definite indications of metastasis to the para-aortic lymph nodes.

Metastatic involvement of one or more of the supraclavicular lymph nodes is the forerunner of metastatic involvement of the peribronchial lymph nodes and is secondary to involvement of the thoracic duct. Enlargement of one or more of these nodes is important. In any case in which the patient is a man, such enlargement should be considered an urgent indication for the examination of both testes. In cases of teratoma, involvement of the supraclavicular lymph nodes occurs much more frequently and earlier in the course of the disease than it does in cases of seminoma.

Enlargement of the inguinal lymph nodes is not definite evidence of metastatic involvement of these nodes in cases of teratoma of the testis. The diagnosis of metastatic involvement of the inguinal lymph nodes should be supported by conclusive evidence that the tumor actually has involved the capsule of the testis and by biopsy of an enlarged lymph node.

In the case in which the tumor had metastasized to bone, the patient complained of pain in his left hip. Roentgenographic examination revealed a destructive lesion of the pubis and ischium on the left side. Operation disclosed an adenocarcinoma, Grade 4, in a teratoma of the right testis.

In 5 cases, the breasts were enlarged and tender. This change is due to an actual proliferation of the mammary tissue which apparently is stimulated by gonadotropic substances in the primary tumor or in the metastatic lesions.

In 28 of the 37 cases in which the tumor had not been treated previously, the involved testis was hard or firm. In 1 of the 37 cases, the involved testis felt normal. In 2 cases the tumor was cystic, and in 2 other cases the involved testis was hard and nodular. The involved testis usually was heavier than its normal mate. Although pain in the testis was a common symptom, palpation of the involved testis seldom disclosed tenderness.

A hydrocele was present in 7 of the 37 cases. A varicocele was present in 2 cases; in 1 of these cases, a hydrocele also was present. In only 1 case did the tumor transmit light and, in this case, light was transmitted poorly.

DIAGNOSIS

Although there are certain clinical differences between malignant teratomas and other tumors of the testis, particularly seminomas, the only way in which a definite diagnosis can be made is by histopathologic examination. The most frequent diagnostic error in any case of tumor of the testis is the failure to consider that a tumor might be present. A few of the diseases that may be confused with a tumor of the testis are tuberculous epididymitis, hydrocele, hernia, gumma of the testis and hematocele. The finding of a firm, smooth or nodular scrotal mass that is about the same shape as a normal testis and does not involve the epididymis should cause one to suspect that a tumor of the testis is present.

No article on tumors of the testis would be complete unless one mentioned the diagnostic and prognostic significance of the excretion of gonadotropin in the urine. The literature on this phase of the subject is very confusing. Different authors have used different units to express the amount of this substance that was present in the urine, and in some articles the gonadotropin in the urine was not determined quantitatively. We agree with the conclusion previously reached by Nash and one of us (E.T.L.); namely, that the value of the tests for gonadotropin is decidedly limited for the following reasons:

1. From the diagnostic standpoint, one cannot confidently predict the histopathologic type of testicular tumor on the basis of either the quantitative or qualitative determination of gonadotropin in the urine. Furthermore, failure to demonstrate abnormal amounts of urinary gonadotropin is not conclusive evidence that a testicular tumor is not present.

2. From the prognostic viewpoint, one cannot exclude metastasis because an excessive amount of gonadotropin is not determined in the urine. It should be men-

tioned, however, that the presence of chorionic gonadotropin in the urine is usually a bad sign and that in cases in which a large amount of this substance is excreted the prognosis usually is unfavorable.

3. The test is too expensive and complex to be used elsewhere than in large institutions.

THERAPY

The surgical treatment of malignant tumors of the testis is extraneous to our field. In different reports, the variation in the percentage of patients who lived five years after operation is difficult to explain. Variations and improvements in surgical treatment make a statistical analysis of such treatment very difficult. Although roentgen therapy has had a tendency to limit the use of radical operation in cases of malignant tumor of the testis, the exact status of surgical treatment and roentgen therapy in cases of malignant teratoma of the testis is very indefinite. As far as we have been able to determine, most American surgeons prefer simple orchectomy to a more radical operation.

In cases of tumor of the testis observed at the Clinic, treatment usually consists of simple orchectomy followed by roentgen therapy. The treatment, of course, is modified to fit the needs of the individual patient. Except in unusual cases or in cases in which the patients are observed late in the course of the disease, simple orchectomy is performed, regardless of whether metastasis has occurred. Orchectomy permits histopathologic examination of the tumor and eliminates such local complications as infection of the tumor. It also removes one source of metastasis. After the patients have recovered from the operation, roentgen therapy is employed.

Roentgen Therapy. The literature on roentgen therapy of malignant tumors of the testis is very confusing. In most of the reports, all tumors of the testis have been classified as teratomas. As we have stated previously, a teratoma is a specific disease entity and should be classified separately. In reports in which roentgen therapy of a malignant teratoma of the testis was mentioned, we could not be absolutely certain that the lesion thus designated was the same as the one which forms the basis of this paper.

Leddy and Desjardins[6] and Nash and Leddy[7] have described the technique of roentgen therapy of tumors of the testis. Some roentgenologists apply the roentgen rays to an inguinal field or to an abdominal field and do not irradiate above the diaphragm unless there is definite evidence that metastasis has occurred at this site. Other authors routinely irradiate the abdomen and thorax. Lumbar and sacral fields commonly are used in cases of malignant teratoma but seldom are employed in cases of seminoma. A total dose of 500 to 4,000 r has been applied to each field. Most roentgenologists prefer to use potentials of about 200 kv., but 130 to 1,000 kv. have been used. The dosage is another problem that has not been settled.

Preoperative Roentgen Therapy. The question of the value of preoperative roentgen therapy has caused considerable controversy among roentgenologists. The proponents of this type of treatment claim that operation may cause metastasis and that preoperative roentgen therapy may seal off the lymphatics and prevent metastasis. The opponents of preoperative roentgen therapy maintain that orchectomy will not cause metastasis if the spermatic cord is clamped at the external inguinal ring and that it will effect a cure if metastasis has not occurred before the operation is performed.

Dean[3] said that he never had observed local recurrence of the tumor in cases in which roentgen therapy was employed before orchectomy was performed. It is well known, however, that the tumor is very likely to recur if it has been incised to obtain a section for microscopic examination. Careful attention to the surgical technique should greatly reduce the possibility of local recurrence or eliminate it entirely.

The most convincing argument in favor of preoperative roentgen therapy is that it

apparently has a tendency to increase the percentage of patients who live for five years after operation. Dean[3] reported that the five year survival rate was 22 per cent greater in cases in which preoperative irradiation was employed than it was in cases in which irradiation was not employed. Randall and Chamberlain[9] said that the five year survival rate was 35 per cent better in cases in which preoperative irradiation was employed but they were not specific about the type of testicular tumor that was present. It is obvious that the relative incidence of radiosensitive and radioresistant tumors will materially affect the survival rates, regardless of whether roentgen therapy is employed before or after operation.

It has been alleged that preoperative irradiation is time consuming and that the constant trauma resulting from the patient's moving about during the period of treatment may cause metastasis.

In cases in which orchectomy is performed before irradiation is employed, the pathologist has an opportunity to examine the tumor before it has been modified by treatment. This is very important from the standpoint of differential diagnosis. According to Dean,[2,3] and Randall and Bothe,[8] a definite diagnosis cannot always be made by microscopic examination in cases in which the tumor has been modified by irradiation.

That a gummatous or a tuberculous testis has on occasion been irradiated as a result of a mistaken diagnosis of tumor is within the realm of possibility. In cases in which there is no evidence of metastatic lesions and in which the amount of gonadotropic hormone in the urine is within normal limits, one might never be certain of the diagnosis after preoperative irradiation. We think that the importance of a correct diagnosis goes far beyond the mere consideration of whether one's records are accurate or not; it will determine the future course of the treatment and will have an outstanding influence on the prognosis.

Within a short period after roentgen therapy first was used in cases of tumor of the testis, it became obvious to many observers that true malignant teratomas are much less susceptible to the action of roentgen rays than are seminomas. This fact was noted by Desjardins, Squire and Morton,[5] who stated that "testicular tumors of the mixed or teratoid type are influenced much less [than seminomas] by roentgen or radium rays. Moreover their susceptibility is a measure of the degree of epithelial preponderance in the cellular composition of such neoplasms. When cartilaginous, myxomatous or fibrous tissue is an important feature the influence of irradiation is light or nil. True teratomas remain practically unaffected by irradiation."

The experience of roentgenologists in the past few years and the results which have been reported bear testimony to the accuracy of these remarks. Although most authors have grouped all types of testicular tumors together in computing survival rates, many have commented on the resistance of teratomas to the roentgen rays. Thus Smith, Dresser and Mintz[11] have noted that "some tumors, chiefly of the teratoma type were extremely resistant to roentgen ray therapy; their metastases changed very little in size even after as much irradiation as the skin would stand." Rosenblatt, Grayzel and Lederer[10] recently reported a series of testicular neoplasms and stated that, despite vigorous postoperative roentgen therapy and the absence of metastasis when the patients were admitted to the hospital, all of their patients who had heterologous tumors died within three years after the onset of symptoms. Ironically enough, 1 patient who was treated by orchectomy alone was living and well seven years after operation. On the brighter side of the picture, it must be acknowledged that irradiation has materially improved the prognosis in cases of seminoma.

RESULTS

In analyzing the results of roentgen therapy, 18 of the 54 cases were excluded.

In 2 of these cases, less than a year had elapsed since the patients were dismissed. The reasons for excluding the remaining 16 cases were as follows: Roentgen therapy was not employed in all of the cases. In some cases, roentgen therapy was employed both before and after the patients came to the Clinic and it was impossible to determine whether the patients had received sufficient roentgen therapy. In other cases, small doses of roentgen rays were employed intentionally. It was of interest to note that in 1 case, in which simple orchectomy was the only treatment employed, the patient was alive twenty-four years after the operation.

The remaining 36 cases were divided into three groups: group 1 includes 17 cases in which treatment was begun before there was any evidence of metastasis; group 2 includes 11 cases in which there was clinical evidence of metastasis when treatment was begun, and group 3 includes 8 cases in which the patients had undergone orchectomy before they came to the Clinic. In all of the cases in the last group, clinical evidence of metastasis was present when the patients first were observed at the Clinic. The results obtained in the 36 cases are shown in Table III. In each instance, the period of survival has been calculated from the date of orchectomy, which was the initial therapeutic procedure in all of these cases.

Group 1. In this group of cases the prognosis obviously should be considered favorable. Treatment consisted of simple orchectomy and postoperative roentgen therapy. Only 8 of the patients in this group were alive five years after orchectomy was performed (Table III) but 1 patient died of meningitis which followed mastoidectomy that was performed fifty-five months after orchectomy. In this case, it may be assumed that the teratoma was cured. The significant feature of the results in this group is that the period of survival did not exceed thirty-one months in cases in which metastasis occurred after orchectomy was performed. The average period of survival of the patients who died was nineteen months. Several of the patients who lived five or more years after orchectomy received roentgen therapy which would be classified as inadequate if judged on the basis of present standards. On the other hand, most of the patients who received intensive roentgen therapy failed to obtain any noteworthy benefit. One patient who received roentgen therapy for metastatic involvement of the peribronchial lymph nodes, which developed after orchectomy, was not benefited at all by this treatment. Roentgen therapy was of little value in this group of cases. We feel that the patients who lived for an appreciable period after operation were fortunate enough to have undergone orchectomy when the teratoma

TABLE III

PERIOD OF SURVIVAL IN THIRTY-SIX CASES OF MALIGNANT TERATOMA OF THE TESTIS*

Group	Patients† Traced	Lived One Year or More After Operation		Patients‡ Traced	Lived Three or More Years After Operation		Patients§ Traced	Lived Five or More Years After Operation	
		Number	Per Cent		Number	Per cent		Number	Per cent
1	17	14	82	16	10	62	14	8	57
2	11	1	9	9	0		6	0	
3	8	4	50	7	1	14	7	0	

* Inquiry as of September 1, 1942.
† Operated on one year or more prior to date of inquiry, that is, September 1, 1941, or earlier.
‡ Operated on prior to September 1, 1939.
§ Operated on prior to September 1, 1937.

still was confined to the testis. In the cases in which the patients died, it seems likely that metastasis had occurred before operation was performed but that the metastatic lesions were not large enough to produce clinical signs or symptoms at the time the patients first were examined at the Clinic.

Group 2. In this group, the results were very discouraging. Only 1 of the 11 patients in this group lived more than a year after orchectomy. This patient lived sixteen months after the operation. In some of the cases the physical condition of the patients was very poor and adequate roentgen therapy could not be employed. The patient who received more roentgen therapy than any other patient in this group lived less than ten months after orchectomy was performed. On the other hand, the patient who survived for sixteen months received only one course of roentgen therapy.

Group 3. In a few of the cases in this group, roentgen therapy had been employed before the patients came to the Clinic. Radium therapy had been employed in 2 cases. In some respects, this group is a composite of groups 1 and 2 as some of the patients undoubtedly had undergone orchectomy before clinical evidence of metastasis had become manifest. The average period of survival after orchectomy was seventeen months. Only 1 patient lived more than three years (forty months) after orchectomy. As roentgen therapy was not begun until thirty-two months after orchectomy, it was not responsible for the comparatively long survival of the patient. In the cases in this group, roentgen therapy produced either transitory improvement or no noticeable improvement.

COMMENT

In approximately half of all cases of malignant teratoma of the testis, there is demonstrable evidence of metastasis when the patients first consult a physician. Patients who have metastatic lesions cannot be cured; in fact, very few of them will live more than three years after they first consult a physician.

SUMMARY

This report is based on a study of 54 cases of malignant teratoma of the testis. A teratoma is a definite disease entity. It apparently is the result of an abortive attempt to form a new individual. It probably originates in the totipotent sex cells or in dislocated blastomeres. The exact cause of this tumor is unknown. Although a malignant change may occur in any part of the tumor, it most frequently occurs in tissue that is derived from the entoderm.

Teratomas of the testis have a tendency to occur in early adult life. In more than 90 per cent in the 54 cases which form the basis of this paper, the patients were less than forty years of age. Metastasis occurs soon after a malignant change has occurred in a teratoma. The only means of making a definite diagnosis of malignant teratoma is by histopathologic examination. We have not had any experience with hormonal tests in cases of teratoma of the testis but we believe such tests are so complex that they can be used only in large institutions.

Although this study is based on a small group of cases, it indicates that the only manner in which a cure can be obtained in cases of malignant teratoma of the testis is by performing orchectomy before metastasis has occurred. This objective can be obtained in less than a third of all cases. After metastasis has occurred, death usually will occur within eighteen months. Roentgen therapy does not appear to have any beneficial effect on malignant teratoma of the testis, which is extremely resistant to roentgen rays.

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REFERENCES

1. CABOT, H., and BERKSON, J. Neoplasms of the testis; study of the results of orchidectomy, with and without irradiation. *New England J. Med.*, 1939, *220*, 192–195.
2. DEAN, A. L., JR. Treatment of teratoid tumors of the testis with radium and the x-ray. *J. Urol.*, 1925, *13*, 149–165.
3. DEAN, A. L., JR. Teratoid tumors of the testis. *J. Am. M. Ass.*, 1935, *105*, 1965–1971.

4. DESJARDINS, A. U. Retroperitoneal lymph nodes; their importance in cases of malignant tumors. *Arch. Surg.*, 1939, *38*, 714–754.
5. DESJARDINS, A. U., SQUIRE, F. H., and MORTON, S. A. Radiotherapy for tumors of the testis. AM. J. ROENTGENOL. & RAD. THERAPY, 1929, *22*, 137–146.
6. LEDDY, E. T., and DESJARDINS, A. U. Radiotherapy for tumors of the testis. *Radiology*, 1938, *31*, 293–298.
7. NASH, L. A., and LEDDY, E. T. Seminoma of the testis from the standpoint of roentgen treatment. AM. J. ROENTGENOL. & RAD. THERAPY, 1943, *50*, 162–196.
8. RANDALL, A., and BOTHE, A. E. Value of preoperative irradiation in tumor of the testis. *Ann. Surg.*, 1937, *105*, 385–391.
9. RANDALL, A., and CHAMBERLAIN, G. W. Results of treatment of testicular tumors; analysis of the advantage of pre-operative roentgen therapy. *Tr. Am. A. Genito-Urin. Surgeons*, 1940, *33*, 297–299.
10. ROSENBLATT, P., GRAYZEL, D. M., and LEDERER, M. Primary malignant tumors of the testicle. *Am. J. Surg.*, 1942, *57*, 94–103.
11. SMITH, G. G., DRESSER, R., and MINTZ, E. R. Radiation treatment of tumors of testicle. *J. Urol.*, 1935, *34*, 462–469.

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EDITORIALS

THE PROBLEM OF THE MOST EFFICIENT THERAPEUTIC APPROACH IN MEDIASTINAL TUMOR

ONLY a few years have elapsed since Potter presented the first miniature roentgenogram of the chest before the Chicago Roentgen Ray Society and the mass survey of segments of the population has already taken such an impetus that the number of persons examined now runs into the tens of millions. In particular, the work done in conjunction with the screening of the personnel inducted into the Armed Forces has proved of inestimable value. The results obtained were so impressive that the procedure is gradually being extended wherever a large group of people can be examined, as for example in industry, shipyards, schools, clinics, and more recently even in private hospitals.

There are two merits of every such survey. The first is that it permits the discovery of a rather large number of unsuspected chest lesions. The percentage of rejections due to anomalies or diseases of the chest for the personnel of the Navy[1] and of the Army[2] was given as varying between 1.65 and 3. Gould[3] in a recent survey conducted for the Tuberculosis Control Section of the United States Public Health Service found in a group of 442,252 individuals 1.1 per cent abnormal nontuberculous chest lesions and in 685,817 examinations 1.4 per cent of reinfection tuberculosis. In the surveys conducted in hospitals the percentage, of course, is much greater. Hodges[4] in 1942 gave an incidence of 8 to 10 per cent, and Bloch and Tucker[5] in 1944 published a report showing that the routine roentgenoscopic examination of the chest among 40,000 patients at the University of Chicago Clinics revealed over 20 per cent pathologic or anomalous conditions of the chest.

The second and perhaps the most outstanding merit of the mass survey is that it permits the discovery of a lesion at a rather early stage of development. In Gould's[3] very extensive work the minimal tuberculous lesions amounted to not less than 60 per cent of the total, making possible the immediate institution of treatment under very favorable conditions. An early discovery is even more important in malignant neoplasms where often a delay of only a few weeks or months means the difference between success and failure. This applies especially to the mediastinal tumors which in their vast majority are composed of extremely malignant and very rapidly metastasizing cellular elements.

It may therefore appear useful to evaluate in the light of the new findings of mass surveys the most efficient therapeutic approach as it applies to mediastinal tumors. Such evaluation is also desirable in view of the fact that the remarkable technical achievements accomplished in the domain of thoracic surgery during the past decade had the effect of changing the indications for roentgen irradiation to no small extent. In a zealousness to radically extirpate or at least explore every intrathoracic tumor the roentgen ray is often relegated to the rôle of a secondary agent applicable only after all other methods have been exhausted. If,

[1] Duncan, R. E. Photofluorographic chest survey of naval personnel. *Dis. of Chest*, 1943, *9*, 269–273.

[2] Ashbury, Howard E., Whildin, James G., and Rogers, Frank T. Roentgenological report of chest examinations made of registrants of U. S. Army Induction Station No. 6, Third Corps Area, Baltimore, Maryland, May 1, 1941 to March 31, 1942. AM. J. ROENTGENOL. & RAD. THERAPY, 1942, *48*, 347–351.

[3] Gould, David M. Nontuberculous lesions found in mass x-ray surveys. *J. Am. M.Ass.*, 1945, *127*, 753–756.

[4] Hodges, F. J. Fluorographic examination of chest as a routine hospital procedure. *Radiology*, 1942, *38*, 453–461.

[5] Bloch, R. G., and Tucker, W. B. Indispensability of routine x-ray examinations of chest in general clinic. *Am. Rev. Tuberc.*, 1944, *50*, 405–417.

for the purpose of establishing proper criteria of operability, a more accurate differentiation between a benign and malignant neoplasm proves necessary, a policy of watchful waiting with checkup roentgenograms at shorter or longer intervals is not infrequently preferred to the immediate institution of roentgen therapy. If no change in size on the successive roentgenograms is noted the tumor is considered more likely benign and the operation is undertaken. Contrariwise the patient is declared inoperable and referred for radiation therapy.

That such an approach can only lead to unsatisfactory results becomes evident from closer study of the nature of mediastinal tumors. In general, they may be divided into those of the posterior and those of the anterior mediastinum. The most common tumors of the posterior mediastinum are the ganglioneuromas, originating from the sympathetic ganglions and the neurofibromas, originating from the spinal nerves. The tumors of the anterior mediastinum arise most frequently from the lymph nodes, mediastinal connective tissue and the thymic gland. Histopathologically they may represent lymphosarcoma, pseudoleukemia, mediastinal manifestations of leukopenic leukemia or lymphatic leukemia, Hodgkin's disease, thymoma, sarcoma, carcinoma of thymic or thyroid origin, teratoma, benign tumors and pseudotumors, such as aneurysm, echinococcus cysts and encysted fluid. As one may see, the cellular components of these tumors show the greatest variation of radiosensitivity. The great majority of them are from extremely to moderately radiosensitive and statistical compilations show that only about 10 per cent fail to exhibit an irradiation response of some degree. For this reason, a waiting attitude with periodical checkup roentgenograms or even an exploratory thoracotomy causes unnecessary postponement of treatment in the greater part of the cases since operation remains a futile effort and irradiation is started at a much later date.

The more efficient method is to institute roentgen therapy at the earliest possible moment as a primary measure. Such a procedure is enhanced by the fact that if a standard dose is given the rate of regression of the various mediastinal tumors can be used within certain limits as a test of differential diagnosis. This so-called "roentgen therapeutic test dose" has been repeatedly described in the literature for the past twenty years. Its practical clinical value has been critically assayed not very long ago.[6] Briefly, it consists in the administration over a mediastinal tumor of the maximum amount of radiation that can safely be tolerated by the normal structures of the chest. Checkup roentgenograms are then made at intervals of two weeks, six weeks, three months, and so forth, following the completion of the irradiation and the rate of regression is expressed in percentage of the size of the original tumor. On the basis of the degree of the radiosensitivity four arbitrary groups are distinguished. In Group I all tumors melt away within two to three weeks. Here belong the tumors having their origin from the highly radiosensitive lymphocyte, such as lymphosarcoma, mediastinal manifestations of leukopenic leukemia, pseudoleukemia and lymphatic leukemia, and the lymphosarcoma of the thymic gland. In Group II there is a 50 per cent or more regression within six weeks and a complete disappearance after a second series of irradiation. This group includes the tumors composed of reticuloendothelial or embryonal spindle cell elements and is practically dominated by mediastinal Hodgkin's disease. Rarely reticulum cell sarcoma, spindle cell sarcoma and endothelioma may also be encountered. In Group III the rate of regression is slow. After two weeks there is hardly any change, after six weeks the regression amounts to from 20 to 50 per cent and after three months there is again increase in size. Most of the remaining malignant tumors belong to this group, such as fibrosarcoma, melanosarcoma, carcinoma of the thymic

[6] Reynolds, L., and Leucutia, T. The value of the roentgen therapeutic test dose in differential diagnosis of mediastinal tumors. Am. J. Roentgenol. & Rad. Therapy, 1942, *48*, 440–466.

and thyroid gland, teratoma, and so forth. In Group IV no change in size occurs during the observed period. It includes all benign neoplasms and pseudotumors. An exception is the fibroma which apparently exhibits the same rate of regression as the uterine fibromas. The most important point in connection with Group IV is that most of the tumors belonging here may be subjected to surgery. In fact, this is the only group where a radical excision may lead to a permanent cure.

A statistical survey of 73 cases of mediastinal tumors primarily treated at Harper Hospital from 1922 to 1936 by the administration of the roentgen therapeutic test dose shows that only 8 cases remained unclassified. In all others the correct diagnosis was eventually established. As far as the final results are concerned, 2 cases out of 15 belonging to Group I, 5 cases out of 16 belonging to Group II, 1 case out of 20 belonging to Group III and 9 cases out of 10 belonging to Group IV survived five years or longer. In 5 out of the 10 benign tumors surgical removal was performed without any difficulty at intervals of from three months to ten years after the administration of the therapeutic test dose. There were in Group IV 4 additional cases which eventually proved to be aneurysms, none having survived the five year period.

What makes the roentgen therapeutic test dose particularly timely is the fact that the mass chest surveys have shown that mediastinal tumors occur more frequently than has been suspected on the basis of the former clinical and postmortem findings. In the vast material of Gould[3] the incidence was given as 0.012 per cent, whereas in the hospital survey of Bloch and Tucker[5] it rose to as high as 0.57 per cent. It is also probable that because of the much earlier recognition of the lesion a substantial increase in the final results may be expected.

Overholt and Wilson[7] in a very recent article paid special attention to the danger of delay of treatment and they laid down some fundamental rules concerning the diagnosis, evaluation and therapy of the three main lesions discovered in mass chest surveys, namely, tuberculosis, cancer of the lung and mediastinal tumors. In regard to the mediastinal tumors they state that the temptation for careful watching is particularly great since the vast majority of the cases have few or no symptoms whatsoever. If a differentiation between the benign or malignant neoplasm cannot be made on the basis of morphologic criteria or the biopsy of the involved lymph nodes or some other more accessible region, as for example the axilla or supraclavicular fossa, they, too, recommend that a therapeutic test dose of roentgen radiation be applied as a primary measure. If a response is noted the tumor is considered malignant and roentgen therapy is continued. If the tumor fails to respond within four to six weeks surgical exploration is undertaken. They further state that it is important to proceed with the excision without delay to avoid the technical difficulties arising from the late effect of the irradiation on the surrounding structures. An exception to this rule is a benign tumor in an elderly person which is operated upon only when subsequent periodic roentgenograms show an increase in size or when the patient unexpectedly develops distressing symptoms.

It appears from all this evidence that neither the policy of watchful waiting nor the delaying exploratory intervention serves a useful purpose in the management and treatment of mediastinal tumors. The chances for cure of the patient are considerably lessened and the advantage of a good survey work eliminated. The immediate administration of a roentgen therapeutic test dose, on the other hand, permits a satisfactory differential diagnosis in most instances and leads to the best permanent results.

T. LEUCUTIA

[7] Overholt, Richard H., and Wilson, Norman J. Silent and masquerading intrathoracic lesions; importance of proper identification of lesions discovered during x-ray surveys. *New England J. Med.*, 1946, *234*, 169–180.

Harris & Ewing Photo

EDWIN ATKINS MERRITT
1880-1946

EDWIN A. MERRITT was born in Red Oak, Iowa, on April 5, 1880, the son of William W. Merritt, a Methodist minister. His ancestry goes back to the earliest days of New England. In many traits of his forceful character he reflected the rugged stock from which he came. One of his most prominent characteristics was a love of freedom and a deep and sincere patriotism. This was a part of his heritage from his English and New England forebears but must have been deepened and intensified

by his early education in Potsdam, New York, in the home of his uncle, General Edwin Atkins Merritt, for whom he was named, and who had a long and honorable career in the Civil War and in the political life of his state. Ed Merritt's love of country was no mere "lip service." When only a boy he enlisted as a private in the Army and served in the Philippine Islands. In the First World War he was a Major in the Medical Corps and at his own urgent solicitation went to France early in 1918. There he was Chief of the Radiological Service of the First Army before and during the entire Argonne offensive and later occupied the same position with the Army of Occupation in Germany with the rank of Lieutenant Colonel. He filled those important positions with the energy and ability that have characterized the work of his entire career.

Soon after the end of the first World War in 1919, Dr. Merritt settled in Washington as the associate of Dr. Thomas A. Groover and Dr. A. C. Christie, an association that endured until his death.

Although Dr. Merritt was a radiologist of great ability in the diagnostic field, his life-long interest was in the treatment of cancer. He had a confidence in the efficacy of radiation treatment of cancer which led him to advocate this method with almost evangelistic zeal. Those who are best acquainted with his results believe that when finally published they will justify his confidence, especially in cancer of the cervix uteri.

In character Ed Merritt was rugged and forceful and at times uncompromising when his convictions were involved. Above everything he hated a sham. At heart he was an idealist who loved people. He looked upon every patient as an individual who was in trouble and in need of his help. He had a great love for beauty in nature which manifested itself in the development of a beautiful garden of over seven acres surrounding his home. In it are innumerable trees and flowers and shrubs many of which he had propagated himself by grafting and hybridization to produce new varieties. In pursuit of this interest he was a member of the American Horticultural Society, the Horticultural Society of New York and the American Orchid Society, and was the author of several articles on horticultural subjects.

In his professional life Dr. Merritt was devoted to the specialty of radiology but primarily he was a physician who had begun his career in general practice. Throughout his life he remained a clinician of unusual ability. He became what must be the ideal of every radiologist, a consultant in medicine who enjoyed the confidence and respect of his colleagues. He was a Fellow of the American Medical Association, a member of the Medical Society of the District of Columbia, the Southern Medical Association, the American Roentgen Ray Society, the American Cancer Society, and a diplomate of the American Board of Radiology.

Edwin A. Merritt was in many respects a unique personality. He had a capacity for friendship that was unusual, a faith in the possibility of progress that never faltered, and a courage in standing for his convictions that never failed. His memory will be cherished by his friends throughout their lives and will be respected and honored by all who knew him.

Arthur C. Christie

ALEXANDER BERKELEY MOORE
1883-1946

IN THE death of Alexander B. Moore, which occurred on March 9, 1946, radiology has lost one of its best known figures. There are few medical leaders in any generation who attain the wide acquaintanceship that fell to the lot of Sandy Moore. This resulted partly from the opportunity he enjoyed for many years at the Mayo Clinic of meeting doctors and patients, not only from all parts of the United States, but from every corner of the world. It was due in larger part to his attractive personality

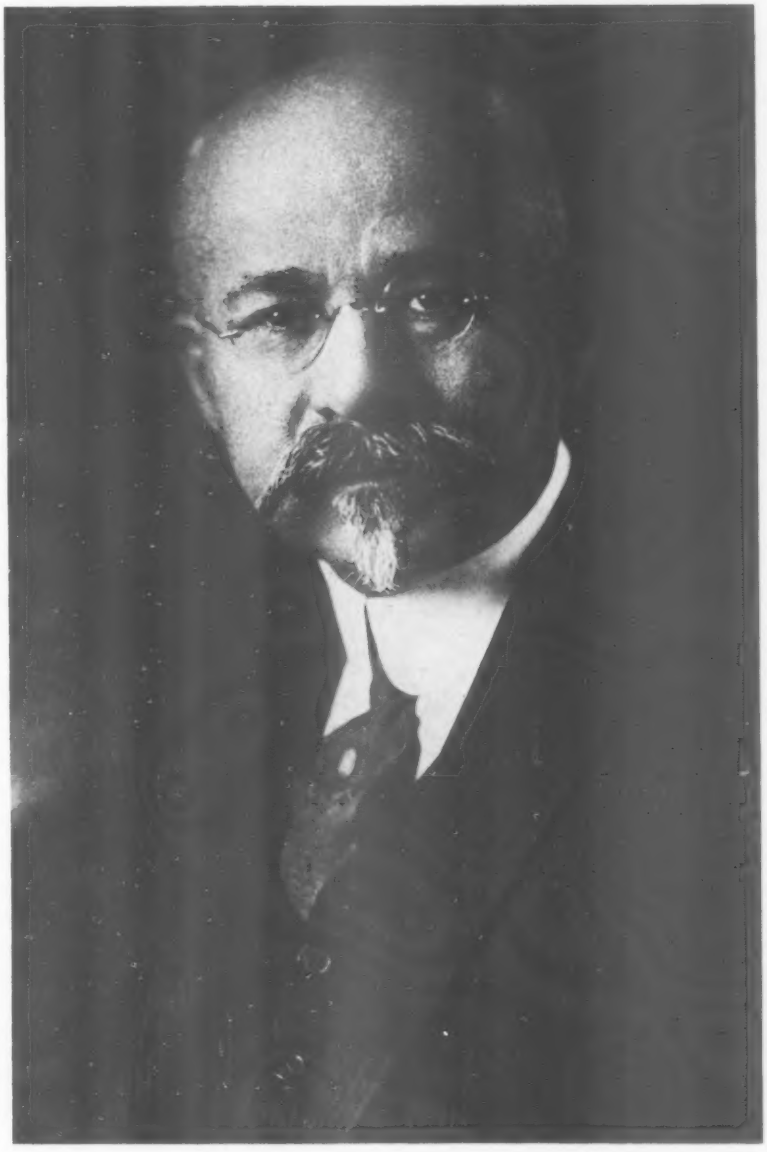
and his capacity for comradeship. Meeting "Sandy" made an impression on both his medical colleagues and on his patients which was likely to persist for years and which gave him a nation-wide circle of life-long friends.

Alexander B. Moore was born in Aldie, Virginia, in 1883. He obtained his medical degree at the University of Virginia in 1907, practiced for a year at The Plains, Virginia, and for a short time in a clinic in Seattle, Washington. In 1909 he entered the radiological department of the Mayo Clinic with which he was identified for more than twenty years. He was on leave of absence from the Clinic during the First World War as a medical officer with the A.E.F. in France where he was at first Radiological Consultant with the First Army and later Chief Radiological Consultant with the Second Army with headquarters at Toul. He returned to the Mayo Clinic in 1919 and in 1926 became head of the radiological department upon the death of Dr. Carman. In 1930 he became associated with Drs. Groover, Christie and Merritt in Washington, D. C., and for the remainder of his life was chief of the radiological department of the Emergency Hospital in that city.

Dr. Moore was a member of the American Roentgen Ray Society and was its President in 1930–1931. He was a member of the Medical Society of the District of Columbia, Fellow of the American Medical Association, Fellow of the American College of Physicians and member of the Radiological Society of North America.

Sandy Moore was a practical roentgenological diagnostician of outstanding ability. He was a keen observer and through many years of careful correlation of roentgen findings with evidence obtained at operation and autopsy he acquired a diagnostic ability, especially in diseases of the chest and gastrointestinal tract, that was equalled by few. His success in diagnosis was due to his power of keen and accurate observation; to his capacity for prolonged, close application to work and study, and to his constant interest in the patient as a person. It was this latter characteristic of the good physician which caused him always to evaluate the roentgen findings of screen and film in the light of the total clinical picture present in the individual case, and it was this which made him a valuable medical consultant. "Sandy" will long be remembered by his medical colleagues for his unusual ability as diagnostician and consultant and those who knew him best will feel keenly the loss of a good comrade and kindly human companion for whom they hold a deep and abiding affection.

ARTHUR C. CHRISTIE



ISAAC LEVIN
1866-1945

ON JUNE 19, 1945, Dr. Isaac Levin, one of the pioneers in the treatment of cancer with irradiation in the United States and one of the early members of the American Radium Society, passed away.

Isaac Levin was born in Sagor, Russia in 1866 of middle class cultured parents. He had a somewhat better than average schooling and was able to attend the Medical Military Academy in St. Petersburg from which he graduated with an M.D. degree in 1890. He was keenly interested in re-

search and to further his knowledge he engaged in post graduate medical studies in Paris, Berlin, Heidelberg and Bern because such study was denied to him in Russia on account of his religion. At that time he married Sophie Block, a graduate of the Russian Conservatory and a concert pianist. In 1891 he came to the United States which offered a better opportunity for a living than that available in Russia. Early in his New York career he became interested in cancer and the alleviation of its victims, especially those among the poor of New York City. In 1910 he was already engaged in cancer research and began to devote almost all his professional time to the field of cancer. He was one of the early private physicians in the City of New York who owned an appreciable supply of radium for therapeutic purposes, and owned the first private radium emanation plant there. At this time, too, he founded the cancer service at Montefiore Hospital in New York City supplying the emanation needed there from his own plant. Dr. Levin was a colorful, forceful character, a stern teacher who believed wholeheartedly in his ideas of cancer and through the medium of various medical societies to which he belonged he disseminated his ideas so persuasively that he was soon carrying out his methods of radiation therapy in numerous institutions throughout the country.

He early recognized the shortcomings of treatment in intra-abdominal malignant neoplasms and the inability of controlling such lesions by the usual methods of irradiation, and in 1921 he devised a new procedure for introducing radon tubules directly into intra-abdominal new growths. This method was the preview of our present day procedures. In 1924, Levin spoke before the American Radium Society and described a new procedure for treating cancer of the cervix with intraperitoneal insertion of glass radon seeds.

In the early 1920's Levin was fortunate in gaining the friendship of Mr. Bird S. Coler, at that time the Commissioner of Public Welfare of the City of New York, to whom he unfolded his long cherished dream of establishing a clinic and hospital especially set aside for the diagnosis, treatment and care of indigent cancer patients of New York City. In 1923 he was able to see the realization of his plans in the establishment of the New York City Cancer Clinic and Hospital, at that time the largest institution of its kind in the world.

Levin early realized the importance of public education in cancer control and in 1923 initiated the formation of the New York Cancer Association, under the auspices of many prominent New Yorkers, to further the study of cancer and allied diseases, to disseminate knowledge of cancer among the medical profession and the lay public, and to give economic assistance to cancer sufferers and to their rehabilitation and to render economic assistance to the patients' families when necessary—a long step in advance in cancer work at that time. From 1912 to 1915 he held the position of Associate in Cancer Research at Columbia University.

Levin readily recognized the importance of early teaching of the knowledge of cancer in the beginning of a physicians' career and sought and obtained a teaching position at New York University where as Clinical Professor of Cancer Research he imparted the newer knowledge of cancer to the younger physicians. This position he held from 1915 to 1933.

Under his leadership, 1923–1930, the New York City Cancer Clinic and Hospital advanced in achievement. He returned in 1930 to private practice and up to the time of his death he remained keenly interested in the general cancer problem, and some of his best publications appeared during this period. From 1925 to 1930 he was the Editor of the *Archives of Clinical Research.*

Dr. Levin rarely missed attending medical meetings dealing with cancer and it was a touching sight, especially in the latter years, to see him at the meetings always accompanied by his devoted wife, an example of most ardent devotion to his every desire. In his latter years of life he was sad-

dened by the sudden accidental death of his son and the loss of his devoted and loyal wife. He leaves two surviving sons.

Dr. Levin was formerly associated with Sydenham, Beth David and Montefiore Hospitals. He was consultant at Lebanon Hospital. He was a member of the following societies: New York County Medical Society, New York State Medical Society, American Medical Association, American Association of Pathology and Bacteriology, American Radium Society, Association of American Physicians, Radiological Society of North America, Society for Experimental Biology and Medicine and American Association for Cancer Research.

Dr. Levin died on June 19, 1945, in New York at the age of seventy-eight. It was a privilege to know him—a most sad feeling to note his passing away.

Ira I. Kaplan

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Netherland Plaza Hotel, Cincinnati, Ohio, Sept. 17–20, 1946.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting, Palace Hotel, San Francisco, Calif., June 29, 1946.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: San Francisco, Calif., July 1–5, 1946.

AMERICAN RADIUM SOCIETY
Secretary, Dr. E. H. Skinner, 1532 Professional Bldg., Kansas City, Mo. Annual meeting: Assembly Hall, Health Center, San Francisco, Calif., June 28–29, 1946.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Palmer House, Chicago, Ill., Dec. 1–6, 1946.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. ASSN.
Secretary, Dr. Roy W. Johnson, 1407 S. Hope St., Los Angeles, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N.Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. F. H. Squire, 1754 W. Congress St., Chicago 12, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. Carroll C. Dundon, 11311 Shaker Blvd., Cleveland, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

DALLAS-FORT WORTH ROENTGEN STUDY CLUB
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. A. Page Jackson, Jr., 1612 Tremont Place, Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Dell, Jr., 333 W. Main St., S., Gainesville, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets annually second Sunday in May.

IOWA X-RAY CLUB
Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

NEW HAMPSHIRE ROENTGEN RAY SOCIETY
Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N.H. Meets four to six times yearly.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. W. H. Seward, Orange Memorial Hospital, Orange, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C.

*** Secretaries of societies not here listed are requested to send the necessary information to the Editor.**

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. Henry Snow, 1061 Reibold Bldg., Dayton, Ohio. Meets during annual meeting of Ohio State Medical Association.

Orleans Parish Radiological Society
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. C. L. Stewart, Jefferson Hospital. Meets first Thursday of each month, October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

Pittsburgh Roentgen Society
Secretary, Dr. L. M. J. Freedman, 4800 Friendship Ave. Meets 6:30 P.M. at The Ruskin on second Wednesday, each month, October to May inclusive.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary Dr. A. M. Popma, 220 N. First St., Boise, Idaho. Mid-Summer Conference, August 8, 9, 10, 1946, at Shirley Savoy Hotel, Denver, Colorado.

St. Louis Society of Radiologists
Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

San Diego Roentgen Society
Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly on first Wednesday at dinner.

San Francisco Radiological Society
Secretary, Dr. Joseph Levitin, 516 Sutter St., San Francisco 2, Calif. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle. Meets fourth Monday each month, October through May, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly, third Thursday evening.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

Mexico

Sociedad Mexicana de Radiologia y Fisioterapia
General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. J. W. McKay, 1620 Cedar Ave., Montreal.

Société Canadienne-Francaise d'Electrologie et de Radiologie Médicales
Secretary, Dr. Origéne Dufresne, 4120 Ontario St., East, Montreal, P. Q.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

South America

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Sociedad Peruana de Radiologia
Secretary, Dr. Victor Giannoni, Apartado, 2306, Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión, Villalta, 218, Lima.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. Babaiantz, Geneva. *Secretary* for German language, Dr. Max Hopf, Effingerstrasse 49, Bern. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

AMERICAN BOARD OF RADIOLOGY

The American Board of Radiology will conduct examinations at the Palmer House, Chicago, Illinois, on November 27 to December 1, 1946. This will be the only examination held during 1946. All those wishing to appear before the Board at this time *must* have their application on file by September 1, 1946.

There are many diplomates and candidates with applications on file whom we are unable to reach from their last known address.

All diplomates of the Board and candidates for examination please notify the office of the Secretary of their present address.

B. R. KIRKLIN, Secretary
American Board of Radiology
Mayo Clinic, Rochester, Minn.

PENNSYLVANIA RADIOLOGICAL SOCIETY

The Thirty-first Annual Meeting of the Pennsylvania Radiological Society was held at the Berkshire Hotel, Reading, Pa., May 17 and 18, 1946. The following papers were presented:

Discussion of Persistent Hyperplasia of the Thymus Gland. Leslie H. Osmond, M.D., Pittsburgh, Pa.

Recent Advances in Technique. George W. Chamberlain, M.D., Reading, Pa.

Atomic Energy in Medicine. Edith H. Quimby, Sc. D., New York.

Treatment of Chronic Cough in Children. E. C. Baker, M.D., Youngstown, Ohio.

Problems Involved in Early Diagnosis of Cancer. Zoe A. Johnston, M.D., Pittsburgh, Pa.

Radiation Hazards Covered by the Safety Code for the Industrial Use of Roentgen Rays. J. L. Weatherwax, M.A., Philadelphia, Pa.

Radiographic Changes in Diseases of the Small Bowel. Burrill B. Crohn, M.D., New York.

Treatment of Carcinoma of the Cervix, with Particular Reference to the Use of the Intracavitary Cone. Samuel G. Henderson, M.D., and Melvin Meyers, M.D., Pittsburgh, Pa.

Bone Changes in the Blood Dyscrasias as Shown by Roentgen Examination. Ralph S. Bromer, Bryn Mawr, Pa.

Clinical and Technical Factors Modifying the Effects of Roentgen Therapy. Robert P. Barden, M.D., Philadelphia, Pa.

Experiences with Malignant Diseases in Young People. Harold W. Jacox, M.D., Pittsburgh, Pa.

Anthracosilicosis—A Study of One Hundred Miners with Seven Year Followup. Louis A. Milkman, M.D., Scranton, Pa.

RADIOLOGY SECTION OF THE CALIFORNIA MEDICAL ASSOCIATION

The Radiology Section of the California Medical Association has elected the following officers for the ensuing year: *Chairman*, Dr. Gordon G. King, San Francisco; *Secretary*, Dr. D. R. MacColl, Los Angeles.

FLORIDA RADIOLOGICAL SOCIETY

At the recent meeting of the Florida Radiological Society the following officers were elected for the coming year: *President*, Dr. Charles M. Gray; *Vice-President*, Dr. James F. Pitman; *Secretary*, Dr. J. Maxey Dell, Jr.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

A CHAIR FOR VERTICAL ENCEPHALOGRAPHY*

By LIEUTENANT COLONEL J. EMERSON NOLL, M.C., LIEUTENANT COLONEL J. M. COTTON, M.C., *and* MAJOR J. N. CREVASSE, C.E.
ARMY OF THE UNITED STATES

ENCEPHALOGRAPHY at times requires examination in the erect position, and, under these conditions, a change to a horizontal position during the course of an examination in the erect position will vitiate the resulting diagnosis by changing the air-fluid relation and the osmotic tensions within the intracranial ventricular system. The chair for encephalography shown in the accompanying photographs was designed to meet the conditions surrounding erect encephalography. The design was drawn to meet the following specifications:

(a) a sufficiently broad base and sufficiently low center of gravity to insure adequate stability (Fig. 1 and 2).

(b) to provide a flat anterior aspect to

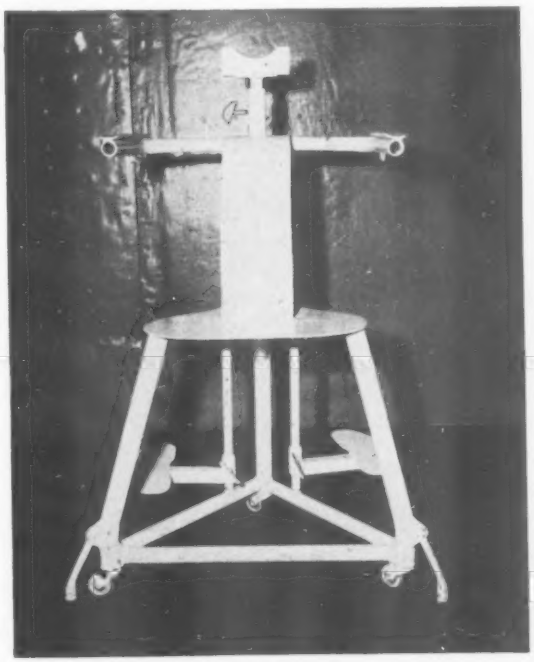


Fig. 1*

Fig. 2. *A*, foot brakes; *B*, brackets for G.I. belts; *C*, adjustable head rest; *D*, arch plate; *E*, foot rests swing to any desired angle and can be raised and lowered; *F*, distance from floor to seat 20 inches; *G*, distance from seat to arms 18 inches.

* The photographs for Figures 1, 2 and 3 were kindly furnished by the Public Relations Office, Foster General Hospital, Jackson, Mississippi.

* From the Department of Radiology, Foster General Hospital, Jackson, Miss.

FIG. 3

make possible close approximation of the patient's head to the erect Bucky grid (Fig. 3).

(c) to provide foot brakes which will enable quick and accurate locking of the chair into any desired position and suitable for use on the average tile covered Army hospital floor (Fig. 2*A*).

(d) to provide brackets for the purpose of accommodating regulation G. I. belts for strapping patients into position on the chair (Fig. 2*B*).

(e) to provide a seat and arm design which will prevent circulatory interference in the anesthetized patient.

(f) to provide an adjustable head rest (Fig. 2*C*).

(g) to provide automatically for an optimum arch of the back for spinal puncture (Fig. 2*D*).

(h) to provide adjustable foot rests (Fig. 2*E*).

(i) to provide for easy draping of the patient for the sterile technique of lumbar puncture.

This encephalographic chair was used as part of the following routine procedure: Patients for encephalography were received in the X-ray Department with differing levels of basal anesthesia. The condition of the patients varied between deep coma and the ability to cooperate to a reasonable degree. The patients were transferred from the stretcher to the encephalographic chair and strapped into position. The previously prepared sterile table, containing the necessary instruments and equipment, was drawn into position alongside the encephalographic chair and the patient's gown was opened in the back and the skin prepared and the patient draped. Lumbar puncture was performed with manumetric readings by an Officer of the Neuropsychiatric Department. Forty-five cubic centimeters of fluid was removed from the spinal canal and 40 cc. of air injected, this being accomplished in fractional parts not exceeding 10 cc. each. At this point an Army x-ray field unit was drawn up to the side of the encephalographic chair opposite to the sterile table and adjusted to take a lateral view of the skull. This film was processed immediately and presented for reading while wet at the end of ten minutes. During this interval, the withdrawal of fluid and the injection of air was continued slowly up to a total of 50 cc. of air, but not exceeding that amount. The need for more than 50 cc. of air was predicated on an evaluation of the prediction encephalogram taken at the 40 cc. level. If the ventricular filling was inadequate, the injection of air continued to the 90 cc. level, at which point a second check-up encephalogram was made by the same method. When the prediction encephalogram at the 40 cc. level or the 90 cc. check-up encephalogram indicated an adequate ventricular filling or when for any reason the further injection of air was contraindicated, the patient was presented for roentgen examination. This was accomplished by removal of the spinal needle and the application of a sterile dressing to the wound. Draperies were removed and clothing readjusted. The chair was then wheeled up to position facing the erect Bucky grid

without disturbing the patient in the slightest degree. Two posteroanterior stereo projections were made at this point. The chair was then rotated 45 degrees clockwise and two left lateral stereo projections were made. The chair was then rotated counterclockwise 90 degrees and two stereo right lateral projections were made. The chair was then rotated so that the original position was reversed, i.e. with the patient in an anteroposterior position. The belt around the patient's waist was then released and the patient's shoulders and head were bent backward until the occiput was in close approximation to the vertical Bucky grid and two stereo anteroposterior projections were made. Full use of the Bucky retention band was made. At the conclusion of this procedure the patient was placed in a horizontal position after which the four stereo views were repeated on the horizontal Bucky grid.

This technique was found to be satisfactory and possesses the following advantage: It makes possible encephalography in a sustained erect position. It insures the minimal amount of air which will provide adequate ventricular filling thereby reducing the postoperative reaction. It also provides minimal handling of the patient and reduces the average overall time for this eighteen film technique, including spinal puncture and manumetric readings to approximately sixty minutes and is clinically satisfactory from the standpoint of the surgeon and radiologist.

CONCLUSION

(1) An original design for a chair for encephalography has been presented.

(2) This chair can be easily duplicated.

(3) The chair provides the mechanical facilities for encephalography in the erect position with a minimal operating time.

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A METHOD FOR BARIUM ENEMA EXAMINATION OF THE PATIENT WITH A COLOSTOMY

By LIEUTENANT COLONEL PERCIVAL A. ROBIN
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GUNSHOT wounds of the intestinal tract constitute about 4 per cent of casualties in World War II. Prompt surgical intervention in the first echelons of medical care results in a low mortality rate from this injury. The practice has been to perform a colostomy when these injuries involve the colon. The convalescence of patients so treated is usually rapid and therefore early evacuation of the patient to the zone of the interior is possible for final definitive care. Whenever feasible, the colostomy is later taken down and normal large bowel function restored.

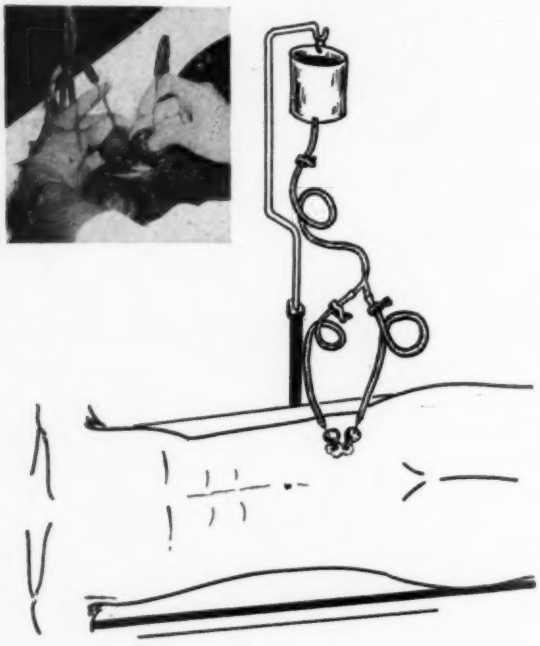

FIG. 1

Before this final surgical care can be instituted, it is necessary to study the colon by means of a barium enema, searching for strictures and other lesions in the large bowel that may have been overlooked previously. This procedure is generally carried out just before the operation.

If the barium enema was introduced per rectum as had been our custom in the past, the portion of the colon distal to the colostomy filled, and barium then spilled over the abdomen saturating the dressings and frequently covering the examination table with barium. The entire roentgenoscopic and film examination was usually distasteful to patient, technician and radiologist because of the unpleasant soilage. Emptying of the distal segment of the colon was usually so rapid that satisfactory roentgenograms were the exception rather than the rule. Finally, the proximal segment of the colon was seldom investigated.

Pendergrass and Cooper[1] recently advocated the use of the rubber bulb, part of an Asepto irrigation syringe, to stopper the colostomy opening and thus permit roentgenoscopic and film study of the distal colon without some of the attendant difficulties mentioned above. Following this lead, certain further improvements in technique are here suggested which will permit a study of the proximal and distal segments of the colon simultaneously.

The technique employed is as follows: The same type rubber bulb is used but the portion normally adapted for the insertion into the syringe is tapered so that it more readily fits into the colostomy opening. If a double barrel colostomy exists, two such rubber bulbs are employed, one fitted into each of the openings. These are maintained in position with large strips of adhesive tape, tightened across the abdomen to exert some degree of pressure, thus giving a more secure seal. Connected to the usual enema can is a segment of rubber tubing which is bifurcated a few feet from the table by a Y.

[1] Pendergrass, R. C., and Cooper, F. W., Jr., Simple method of study of the colon in the presence of a colostomy. AM. J. ROENTGENOL. & RAD. THERAPY, 1944, *52*, 563.

shaped glass tube. To each side of the glass tube is connected a 2 foot section of rubber tubing with an attached 15 gauge needle. Three clamps are used, one on the main tubing and one on each branch. The needles are forcibly introduced into the rubber bulbs, carefully noting which bulb leads to the proximal segment of the colon and which one to the distal (Fig. 1).

The clamp on the tubing which connects the needle to the distal segment of the colon is released. The barium from the enema can flows very slowly into the distal portion of the colon. It is well to mention at this point that rather thin barium is preferable, otherwise the flow through the comparatively small gauge needle is too slow. When the distal segment of the colon is completely visualized under roentgenoscopic observation, the tubing is clamped off and the clamp on the tubing connected with the proximal segment of the colon is then released. The filling of this portion of the colon is observed roentgenoscopically and the barium is allowed to flow to the cecum and into the terminal ileum if possible. The needles are then withdrawn from the rubber bulbs and routine pre-evacuation roentgenograms of the colon are made in the anteroposterior position. Finally, the patient withdraws the rubber bulb stoppers and the barium is evacuated from both loops of the colon through the colostomy into a urinal.

The method thus outlined affords the radiologist an unhurried opportunity to study the entire large bowel roentgenoscopically. The slow filling of the colon is advantageous because it prevents sudden distention of the colon with the usual attendant discomfort to the patient as is the case when the barium enema is introduced in the routine manner. The resultant film is quite comparable to the routine roentgenograms of the colon (Fig. 2). Several lesions of the proximal portion of the colon which could not be visualized by the previous methods have been observed, and these findings have been of inestimable aid to the surgeon in his evaluation of the case.

Fig. 2. Roentgenogram of the colon with the rubber bulbs visualized connected to the proximal descending portion of the colon.

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INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

STUART, E. A.: Otolaryngologic aspect of frontal meningocele 785
GREEN, J. R., and OLDBERG, E.: Injuries of vertex of skull 785
PERLOFF, W. H., ROSE, E., and SUNDERMAN, F. W.: Therapeutic observations in Cushing's syndrome 786
MOORE, M. T.: Morgagni-Stewart-Morel syndrome 786
KAPLAN, A.: Traumatic pneumocephalus with spontaneous ventriculograms 787
WYCIS, H. T.: Basilar impression (platybasia) 787
HAYMAKER, W., and FOSTER, M. E., JR.: Intracranial dural cyst 787
TURNBULL, F.: Extradural cerebellar hematoma 787
INGRAHAM, F. D., and BAILEY, O. T.: Cerebellar medulloblastoma with verification nineteen years after onset of symptoms 787
HARA, J. R.: Ossifying fibroma of superior maxilla 788
FIGI, F. A., and ROWLAND, W. D.: Primary tumors of Stensen's and Wharton's ducts 788

MISCELLANEOUS

BRAESTRUP, C. B.: Industrial radiation hazards 789
HENSHAW, P. S.: Leukemia in mice following exposure to x-rays 789
MARCH, H. C.: Leukemia in radiologists 790
HENSHAW, P. S., and HAWKINS, J. W.: Incidence of leukemia in physicians 790
MACKEE, G. M., MUTSCHELLER, A., and CIPOLLARO, A. C.: Time factor in irradiation 790
MACKEE, G. M., MUTSCHELLER, A., and CIPOLLARO, A. C.: Area factor in roentgen irradiation 791
MORGAN, R. H.: Quantitative study of effect of temperature on sensitivities of x-ray screens and films 791
HENSHAW, P. S.: Influence of irradiation-killed cells on tumor growth 792
HENSHAW, P. S.: Experimental roentgen injury. I 792
HENSHAW, P. S.: Experimental roentgen injury. II 792
HENSHAW, P. S.: Experimental roentgen injury. III 793
HENSHAW, P. S.: Experimental roentgen injury. IV 793
MACKEE, G. M., CIPOLLARO, A. C., and MUTSCHELLER, A.: Shock-proof roentgen ray apparatus in dermatology 794

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

STUART, E. A. Otolaryngologic aspect of frontal meningocele. *Arch. Otolaryng.*, Sept., 1944, *40*, 171–174.

Frontal meningocele is rarely encountered, but it must be considered in the differential diagnosis of the various fronto-orbital conditions for which patients may seek advice. Frontal meningocele is usually congenital in origin and therefore precedes any development of the frontal sinuses. (The author reports 1 case which illustrates the possibility of the meningocele occurring as a result of trauma. It is therefore impossible to rule out frontal meningocele simply because the lesion in question has occurred after birth.)

Only 4 cases of frontal meningocele have been recorded in the files of the Royal Victoria Hospital and the Montreal Neurological Institute. In each of these cases treatment was sought during the first year of life. In 2 of these cases there was marked widening of the interorbital space.

Differential Diagnosis. Hypertelorism, a craniofacial deformity with marked separation of the eyes. Greig first described this condition in 1924. He considered the primary cause to be a developmental abnormality of the sphenoid bone.

Epidermoid cyst (or cholesteatoma) of the frontal sinus. This condition usually occurs in the outer half of the orbit and is present at birth.

Mucocele of the frontal sinuses occurs, of course, only after the frontal sinuses are developed.—*Mary Francis Vastine.*

GREEN, JOHN R., and OLDBERG, ERIC. Injuries of the vertex of the skull with special reference to the paracentral lobules of the brain. *Surg., Gynec. & Obst.*, Sept., 1944, *79*, 267–275.

Disturbance of certain somatoautonomic functions of the paracentral lobule region of the cerebrum may be easily confused with lesions of the spinal cord. The literature on this subject is reviewed and 2 cases are reported.

Anatomical Considerations. The paracentral lobules are formed by continuations of the precentral and postcentral gyri on the medial aspects of the brain. The anterior half belongs to the frontal lobe and the posterior half belongs to the parietal lobe.

Arterial blood reaches the paracentral lobule from a branch of the anterior cerebral artery. Under normal conditions the venous blood empties into the superior longitudinal sinus. If this pathway is gradually obstructed, a fairly efficient collateral circulation is maintained by veins which anastomose freely with the lateral cerebral veins.

Pathological Features. The most common type of military injury occurs as the result of a gutter or tangential wound at the midline of the head. In civil life the injury is more likely to be produced by a direct blow to the vertex. Usually both tables are depressed causing a spoon-shaped depression in the skull. Exposure of the superior longitudinal sinus in such cases usually reveals the presence of a thrombus in the sinus.

Circulatory disturbances in the paracentral lobules may be caused by a number of conditions other than traumatic lesion, viz., neoplasms, particularly the parasagittal meningiomas, thrombosis of a superior cerebral vein without involvement of the superior longitudinal sinus and thrombosis of the anterior cerebral artery.

Physiology of the Paracentral Lobules. The cerebral centers for the rectal and urinary sphincters are probably located in the paracentral lobules. Damage to these areas may be manifested by an inability to initiate or to stop micturition voluntarily or by an inability to appreciate bladder distention.

Clinical Considerations. Traumatic lesions which occur in the region of the vertex of the skull may injure the paracentral lobules directly or cause damage indirectly by means of venous obstruction.

The majority of cases show little change in consciousness. This fact, together with the loss of function of the legs, bladder, and rectum may initially suggest the presence of pathology in the spinal cord rather than in the cerebrum.

The symptoms and signs of increased intra-

cranial pressure are usually lacking although many of the patients complain of headache.

In the upper extremities the proximal segments are the most severely affected and recover last. The muscles of the back are frequently involved so that the patient can neither sit up nor move about in bed. The paralysis of the legs is the converse of that in the arms; thus the distal segments suffer most and recover last. The marked rigidity of the affected extremities is a striking feature.

The association of motor and autonomic disturbances (e.g., dysfunction of urinary bladder, rectal, and sexual mechanisms) with these lesions of the paracentral lobules has received little emphasis up to this time.—*Mary Frances Vastine.*

PERLOFF, WILLIAM H., ROSE, EDWARD, and SUNDERMAN, F. WILLIAM. Therapeutic observations in Cushing's syndrome; effect of various agents on calcium, phosphorus and nitrogen excretion in a patient with pituitary basophilism. *Arch. Int. Med.*, Oct., 1943, *72*, 494–505.

The case of a thirty year old woman with pituitary basophilism in whom skeletal changes were particularly striking and in whom the diagnosis was reached by exclusion is reported. The skeletal changes were those of demineralization and compression fractures of the vertebrae. Prolonged metabolic studies were made on the patient. Such studies were made at intervals from February, 1941, until April, 1942, with the following purposes in mind: (1) to observe the effects of varying calcium-phosphorus ratios in the diet and of various combinations of therapeutic agents on the excretion of calcium, phosphorus and nitrogen; (2) to determine the effect of such dietary and therapeutic combinations on the serum concentration of calcium, inorganic phosphorus and protein and the activity of phosphotase in the serum; (3) to observe the effect of such treatment on the patient's symptoms and clinical course.

Certain striking objective and subjective changes occurred during the course of the patient's treatment. The subjective changes included a definite increase in muscular strength and improvement in the backache following the prolonged period (123 days) treatment with calcium gluconate, vitamin D and testosterone. At the same time there was noted deepening of the voice, enlargement of the clitoris and marked increase in the facial acne and hirsutism. The hirsutism decreased when the use of testosterone was stopped. The objective changes was stopped. The objective changes noted after prolonged testosterone therapy included amelioration of the diabetes with improvement of the tolerance for dextrose and some recalcification of the spine and increase in the urinary excretion of 17 ketosteroids to 25 milligrams per twenty-four hours.

Other definite objective changes were: (1) loss of calcium chiefly through the urine when the calcium intake was low; (2) ability to retain intravenously administered calcium; (3) retention of calcium and increased retention of phosphorus following large doses of vitamin D; (4) retention of nitrogen during and after the first phase of testosterone therapy whereas less marked retention of nitrogen was noted following its continued use for a period of 123 days; (5) negative calcium balance, increase in fecal phosphorus and retention of nitrogen after the administration of diethylstilbestrol.

The authors conclude that the theory propounded by Albright *et al.* of protein deficiency as the basis of the osteoporosis of Cushing's syndrome still lacks proof although some evidence in its favor exists.—*J. J. McCort.*

MOORE, MATTHEW T. The Morgagni-Stewart-Morel syndrome; report of a case with pneumoencephalographic findings. *Arch. Int. Med.*, Jan., 1944, *73*, 7–12.

The author reports this case to illustrate failure to recognize the condition over a period of many years because of the slow progress and apparently innocuous nature of the disease which was euphemistically dismissed as a harmless psychoneurosis. The patient was a thirty-nine year old married woman admitted with the chief complaints of headaches and attacks of drowsiness accompanied by convulsive seizures. The patient had menstrual irregularities and imbalance of the vegetative nervous system. Laboratory studies showed an abnormal calcium-phosphorus ratio, a high blood cholesterol level, a low basal metabolic rate, and disturbed sugar tolerance. Thus, there was indication of both a metabolic and endocrine disturbance.

Pneumoencephalograms showed pronounced cortical atrophy over the frontal and parietal lobes, atrophy of the islands of Reil, and moderately advanced internal hydrocephalus with asymmetry and irregularity of the lateral ventricle. The skull itself showed an increased

thickness and density of bone throughout the frontal, parietal and occipital regions. In addition there were irregular hyperostoses of the inner table of the frontal and parietal bones. The sella turcica was small and the clinoid processes were almost completely bridged. Study of the encephalogram showed that the areas of cortical atrophy were not in direct contact with the hyperostoses at all points but that fluid-filled spaces existed between the inner table of the skull and the brain. This observation would seem to rule out the theory that the pressure exerted by the hyperostoses results in cortical degeneration; it would also preclude the contention that the hyperostosis fills in the "dead space" as a compensatory mechanism.—*J. J. McCort.*

Kaplan, Abraham. Traumatic pneumocephalus with spontaneous ventriculograms. *J. Neurosurg.*, May, 1944, *1*, 166–170.

Kaplan reports a case of traumatic pneumocephalus associated with a fracture of the right frontal bone and cribriform plate in a thirty year old male. Cerebrospinal rhinorrhea and a well outlined ventricular system were present. Repair of the defect was accomplished with complete recovery save for persistent anosmia. Pneumocephalus most often follows fracture of the posterior wall of the frontal sinus or cribriform plate. Cerebrospinal rhinorrhea with pneumocephalus may occur spontaneously in a patient with congenital arachnoid projections about the olfactory nerve. In pneumocephalus air may be trapped in the subdural, subarachnoid or ventricular systems or it may enter the brain substance. Other trauma such as intranasal manipulation, craniotomy, local inflammatory lesions, osteomatous erosion, or downward projection of a pituitary neoplasm may produce pneumocephalus. Chemotherapy has altered the outlook; untreated cases have a mortality of 40 to 50 per cent. Spontaneous cure may occur, surgical repair of cases of rhinorrhea should be attempted early.—*Leo A. Nash.*

Wycis, Henry T. Basilar impression (platybasia); a case secondary to advanced Paget's disease with severe neurological manifestations. *J. Neurosurg.*, Sept., 1944, *1*, 299–305.

Basilar impression producing neurological findings has been reported not infrequently. A case secondary to Paget's disease in a fifty year old white male with severe neurological manifestations which was successfully treated by high cervical laminectomy and suboccipital decompression is reported by Wycis. Chamberlain's report and excellent comments concerning these cases generally is included.—*Leo A. Nash.*

Haymaker, Webb, and Foster, Miles E., Jr. Intracranial dural cyst. *J. Neurosurg.*, May, 1944, *1*, 211–218.

Cysts located solely in the dura are rare. One in the spinal dura has been recorded. Cysts near the dura, however, have often been reported. Haymaker and Foster report a case of an intradural cyst located in the occipital region producing severe pain and blurred vision in a thirty-four year old soldier. The lesion had eroded the occipital bone as seen on plain roentgenograms. The patient was explored and the cyst drained. Death due to infection occurred some weeks later. The lesion proved to be intradural and unilocular about 9 by 6.5 cm. in size, with walls from 2 to 3 mm. in thickness above and below the level of the tentorium and on both sides of the midline. The authors suggest that the cyst was formed by failure of the two layers of the dura to unite in fetal life.—*Leo A. Nash.*

Turnbull, Frank. Extradural cerebellar hematoma. *J. Neurosurg.*, Sept., 1944, *1*, 321–324.

Turnbull reports a case of a subacute or delayed post-traumatic extradural cerebellar hematoma which presented signs of a cerebellar lesion and which was successfully removed. Ventriculography revealed moderate internal hydrocephalus. He cites the rarity of the location of this lesion.—*Leo A. Nash.*

Ingraham, Franc D., and Bailey, Orville T. Cerebellar medulloblastoma with verification nineteen years after the onset of symptoms. *J. Neurosurg.*, July, 1944, *1*, 252–257.

Because the characteristics of medulloblastomas have been so firmly established as solid midline cerebellar tumors of childhood with rapid progression, Ingraham and Bailey report a case which departs clinically in almost all respects from the usual behavior of this tumor. The authors' summary is as follows: "A cystic tumor was demonstrated by aspiration of fluid in the cerebellum of a girl of 15 in 1924. Roentgen therapy, of inadequate dosage, was given in

1926 and 1927. Symptoms recurred in 1927, but improved after negative exploration. Following another asymptomatic interval, symptoms again appeared in 1943. At that time, a medulloblastoma was demonstrated. This patient thus presents marked deviation from the usual syndrome of cerebellar medulloblastoma."—*Leo A. Nash.*

HARA, JAMES H. Ossifying fibroma of the superior maxilla. *Arch. Otolaryng.*, Sept., 1944, *40*, 180–188.

Ossifying fibroma is a rare benign tumor of nondental origin. Fibroma of this type is mixed with osseous elements in varying amounts. Ewing called this type of growth secondary osteoma since it appears as a result of secondary ossification of the connective tissue.

Genesis of the Tumor. Ossifying fibroma develops in the spongiosa. The exact mode of its origin is not definitely known. Phemister and Grimson stated that the growth is a true neoplasm and not a form of osteitis fibrosa, hyperostosis or chronic inflammation. A number of writers have noted an association with carious teeth. Others have mentioned facial trauma as a predisposing factor.

Symptoms and Physical Signs. The disease occurs in women much more frequently than in men. The tumor grows slowly. It usually involves one side of the superior maxilla. In one group the site of predilection is in the anterolateral portion of the upper jaw, including the alveolar process. In the second group the tumor invades the hard palate, occasionally causing dysphagia. The tumor shows no tendency to metastasize. No case has been recorded in which it became malignant.

Roentgenographic Diagnosis. The contour of this tumor is always smooth. Roentgenologically, two distinct types of ossifying fibroma may be recognized: (1) circumscribed and (2) diffuse. The maxilla is markedly enlarged and the cortex is thinned. There is no periosteal reaction. Depending on the age of the patient and on the amount of calcification, the tumor appears to vary from diffuse haziness to complete ashy density. In the 3 case reports given, the lower half of the affected maxillary sinuses appeared diffusely clouded.

Macroscopic and Microscopic Examinations. The ossifying fibroma is soft yet firm at operation. The cutting knife gives the operating surgeon a sensation not unlike cutting into a raw potato. The tumor is moderately vascular. It has no distinct capsule. It is creamy in color. Histopathologically, the growth consists of abnormal bony trabeculae, thin and irregular, scattered in a stroma of abnormal connective tissue.

Treatment. Aaron reported a case in which ossifying fibroma was successfully treated with a large dose of radiation. However, the treatment of choice is surgical removal. Phemister and Thoma caution against sacrificing too large an area in removal. When the tumor involves the alveolar ridge it is curretted down to the dental roots, but the teeth are spared. In selected cases, small fractional doses of radiation may be given following the operation. The preferable method of removal is that of careful excision of the growth with cauterization of the surrounding area.

Summary. Three tumors diagnosed as ossifying fibroma of the superior maxilla occurred in two women, aged twenty and twenty-nine, and a boy fourteen years of age. These cases are reported.—*Mary Frances Vastine.*

FIGI, FREDERICK A., and ROWLAND, WILLARD D. Primary tumors of Stensen's and Wharton's ducts. *Arch. Otolaryng.*, Sept., 1944, *40*, 175–176.

Tumor arising in Stensen's or in Wharton's duct is rare. A review of the literature has failed to reveal any reports of a tumor primary in either of these locations. In all probability the condition is not as unusual as this fact might indicate, however, for one fairly frequently encounters in the floor of the mouth a malignant neoplasm that is too far advanced to permit of recognition of the site of origin. Two cases of adenocarcinoma of the main salivary ducts have come under the authors' observation in recent years. In addition two inflammatory nodules occurring without associated salivary calculi have been encountered in these structures. Clinically the latter nodules were indistinguishable from true neoplasms.

Symptoms. The symptoms complained of in the cases of true neoplasm were not uniform. In 1 case they were those characteristic of recurring obstruction in Stensen's duct. Sudden pain with tenderness and swelling in the parotid region was induced by eating, terminating spontaneously with a gush of saliva into the mouth and a foul taste. In the other case of adenocarcinoma of Wharton's duct, the patient

had noted two small tender nodules in the right side of the floor of the mouth situated anteriorly along the course of the submaxillary salivary duct. These had increased steadily in size but had not produced evidence of obstruction to the flow of saliva.

Differential Diagnosis. A salivary calculus lodged in Stensen's or Wharton's duct is the principal consideration in differential diagnosis. On palpation the consistency of the tumor is indistinguishable from that of a calculus. The possibility of a calculus being present and accounting for the findings can be excluded only by means of roentgenograms made with large dental films inside the mouth. A roentgenogram not showing a pronounced shadow should immediately suggest the possibility of neoplasm.

Anatomy of the Tumors. The tumors in these cases were firm, movable, tender, slow-growing and each appeared to be encapsulated within the wall of the duct, so that they were relatively easy to remove. Histopathologic study was necessary for definite recognition, and excision was carried out for this purpose as well as for therapeutic reasons.—*Mary Frances Vastine.*

MISCELLANEOUS

Braestrup, C. B. Industrial radiation hazards. *Radiology*, Sept., 1944, *43*, 286–292.

The use of radiation in industry has increased to such an extent that more is now used in industry than in medicine. It is important therefore that industrial workers be protected from the action of radiation which caused so many fatalities among the earlier workers in medical radiology.

On the basis of experience in medical radiology it was calculated that a dose of 0.2 r per day could be borne without injury. The daily tolerance dose recommended by the Bureau of Standards, however, in their Handbook on the subject issued in 1938 is 0.1 r per day. And in industry not only the voltages used should be taken into consideration but also the other factors of milliamperage, target distance and exposure time. Charts are given showing the thickness of lead required for protection with different voltages, milliampere-minutes and distances, assuming a daily tolerance dose of 0.1 r. A table is also given showing the results of protective measurements at 400 and 1,000 kilovolts, the necessary amount of protection being given for different exposures per day indicated in milliampere-minutes and corresponding milliamperages for continuous operation. Concrete may also be used as a protective material, particularly for the higher voltages or where it is already a part of the building construction. If a worker is exposed to the action of several tubes at the same time the protection of each tube should be calculated for all of them.

Scattered radiation from the objects to be irradiated or from the floors, walls and ceilings of the buildings must also be considered. As scattered radiation is approximately proportional to the area irradiated it is important to limit the cross section of the beam to the actual requirements. In some cases it has been possible to cut the stray radiation to half merely by adding a lead diaphragm to the aperture of the tube. Reduction of scatter also improves the quality of the roentgenograms.

Radium protection requires practically the same precautions as those used for roentgen protection.

Often injurious results are not due to defective equipment but to ignorance or carelessness on the part of the personnel. Technicians should be trained carefully in safe operative procedures. Stray radiation should be checked at regular intervals. This may be done by having the workers carry dental films on different parts of the body for about a month and checking the density of the test films with that of control films with a known exposure. Pocket ionization chambers may be used in place of the films if greater accuracy is necessary.—*Audrey G. Morgan.*

Henshaw, Paul S. Leukemia in mice following exposure to x-rays. *Radiology*, Sept., 1944, *43*, 279–285.

The author studied the relationship of irradiation to leukemia in C57 Black mice. This strain was used because they show a normal incidence of leukemia of not more than 10 per cent. The term leukemia is used in this article to cover not only the myeloid, lymphoid and monocytic forms, but also lymphomatosis, lymphosarcoma, lymphadenosis and pseudoleukemia.

The mice were given doses of 200 r over the whole body every four weeks until six doses had been given. At this time the leukocyte count was dangerously reduced (1,000 per cubic millimeter or less) and the animals were in a cachectic condition. Leukemia was found in 29.8 per

cent of these animals and in only 7 per cent of non-irradiated controls.

Graphs showing blood controls are given and microphotographs showing the leukemia findings. The irradiation destroys blood-forming tissue and results in leukopenia. If the damage is not too severe recovery takes place over a period of months and following this regenerative process hyperplasia and neoplasia of the hematopoietic tissues develops, which may or may not be accompanied by marked leukocytosis. Hyperplasia of various hematopoietic tissue was seen, most frequent in the thymus but varying in distribution in different animals. There was invariably invasiveness of leukocytes from normal sites into adjacent tissues. As a rule, the cell forms were undifferentiated and indeterminate. The cell types was not the same for all animals though they were given the same treatment under the same conditions.—*Audrey G. Morgan.*

MARCH, HERMAN C. Leukemia in radiologists. *Radiology*, Sept., 1944, *43*, 275–278.

For some years there has been an impression that exposure to radiation might cause leukemia. Twenty-three cases of leukemia following irradiation have been reported in the world literature but in some of these details were lacking and the causal relationship was not established.

The author was impressed by the death of 3 radiologists from leukemia during 1943. He therefore made a study of the deaths of radiologists reported in the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY and in *Radiology* for the past fifteen years and found that among 175 deaths, the cause of which was reported in 173, 8 deaths had been caused by leukemia. This gives an incidence of 4.57 per cent for all types of leukemia in radiologists for the past fifteen years. The incidence of deaths from leukemia among physicians not practicing radiology during this same period was 0.44 per cent. The incidence of leukemia therefore among radiologists was more than ten times that among among physicians not practicing radiology. A statistical analysis shows that there is only one chance in a million of getting 8 cases of a condition by chance alone in a group of 175 cases, when the standard rate of incidence is 0.441 per cent.

The author suggests that the deaths and major illnesses of all radiologists be recorded by some central agency so that the relationship between prolonged irradiation and various pathological conditions may be established.—*Audrey G. Morgan.*

HENSHAW, PAUL S., and HAWKINS, JAMES W. Incidence of leukemia in physicians. *J. Natl. Cancer Inst.*, Feb., 1944, *4*, 339–346.

On the basis of evidence in the literature suggesting that high energy radiation may increase the incidence of leukemia in (1) radiation workers under conditions resembling those in which radiation carcinoma has developed and in (2) animals experimentally exposed to roentgen rays, a study was made by the authors of the incidence of leukemia in physicians by comparing the incidence of this disease with the occurrence in the general population.

Data were obtained from the death lists of the *Journal of the American Medical Association*, from the mortality reports of the United States Bureau of the Census, and an unpublished compilation of the United States Public Health Service. Comparisons were made on the basis of (1) the ratio of deaths from leukemia to deaths from cancer, (2) ratio of deaths from leukemia to total death rates, and (3) death rates from leukemia. Curves were plotted in each of these groupings and differences in incidences were noted. After corrections were determined, leukemia was recognized approximately 1.7 times more frequently among physicians than among white males in the general population.

The authors state that it is not definitely known that radiation is responsible for the apparently higher incidence among physicians, but that this finding is in accord with the findings on experimental animals in which exposure to roentgen rays has been found to increase the incidence of leukemia.—*Harry Hauser.*

MACKEE, GEORGE M., MUTSCHELLER, ARTHUR, and CIPOLLARO, ANTHONY C. Time factor in irradiation. *Arch. Dermat. & Syph.*, April, 1943, *47*, 490–497; correction, May, 1943, *47*, 762.

Holthusen in 1933 published a curve showing a definite relationship between biologic effect and the intensity rate of irradiation. This was the first proof of such a relationship. His curve is reproduced and the authors describe their experiments which show that the effect is dependent not only on intensity rate but also on

time. They irradiated adjacent areas of skin, keeping time and rate constant on one and varying one of the factors on the other, while keeping the second factor constant. They used unfiltered radiation with 52 kv. and 10 ma. and a half-value layer of 0.5 mm. aluminum in one series and 100 kv., 5 ma. and a half-value layer of 0.8 mm. aluminum in the other. A table and graph are given showing the results of their experiments. They confirmed Holthusen's results in regard to the influence of intensity rate on effect and also showed that time has an effect on the biologic response of tissue to irradiation. They show that the decreased effectiveness of radiation at lower intensities is due to healing or recovery during the irradiation. A latent amount of radiation has to be given before any cells are destroyed. For human skin the latent dose is approximately 130 roentgen minutes. This must be subtracted in calculating quantitative results.—*Audrey G. Morgan.*

MacKee, George M., Mutscheller, Arthur, and Cipollaro, Anthony C. The area factor in roentgen irradiation. *Arch. Dermat. & Syph.*, May, 1943, *47*, 657–664.

It has been known that the size of the area irradiated has an influence on the effectiveness of the irradiation but no definite figures for this relationship had been worked out. As this area factor is important in the treatment of skin lesions, the authors made physical determinations of the amounts of radiation required to produce identical reactions on different sized skin areas. Tables and graphs giving the details of their results are published. They irradiated two skin areas on the same subject, one area being kept uniform in size and the size of the other varied by the use of protecting lead masks. When 52 and 100 kv. of unfiltered radiation were used the area of reaction was 1.5 mm. smaller than the area exposed; with 120 kv. and 3 mm. aluminum filter it was 3 mm. smaller. With increase of voltage and filtration the proportion of the area of reaction to the area exposed decreased progressively. Therefore to cover all parts of a small lesion the diameter of the exposed field must be extended 1.5 mm. beyond the lesion for unfiltered radiation and 3 mm. for slightly filtered radiation. The variation in area with nonfiltered or slightly filtered radiation is slight with areas of more than 2 sq. cm. and with highly filtered radiation it is slight with areas of over 10 sq. cm.

It is assumed that secondary radiation from the exposed tissues to adjacent non-exposed tissue causes a decrease of intensity near the border and surface of the exposed tissue. The mathematical equation based on this assumption is worked out and the values found experimentally agree closely with the values calculated theoretically.

In accordance with these facts radiation of high voltage and heavily filtered radiation through small openings would give rise to an intensified triangle in the deep tissues and to greatly reduced action of the radiation at or near the surface of the skin. This problem is being studied further and a report will be made on it later.—*Audrey G. Morgan.*

Morgan, Russell H. A quantitative study of the effect of temperature on sensitivities of x-ray screens and films. *Radiology*, Sept., 1944, *43*, 256–266.

This study is concerned with the relationship between temperature and the brilliance of fluorescent screens and the sensitivities or speeds of roentgenographic films exposed with intensifying screens and with roentgen rays directly. A diagram of the thermal chamber used in studying the effect of temperature on the brilliance of fluorescent screens is given and curves showing the effect of a considerable range of temperatures on different types of fluorescent screens. Curves are also given showing the effect of temperatures on roentgenographic films exposed with and without intensifying screens.

At the levels of intensity used in chest roentgenography the effect of temperature on the sensitivities of the various film-screen combinations is negligible below 25° C. Above room temperature the amount of radiation required to give a given radiographic effect rises slowly until at 60° C. it is 50 to 100 per cent higher than at room temperature. At low levels of intensity (the conditions at which lateral lumbar spine films are made) the effect of temperature is even more marked.

Over great ranges of temperature such as may be met with in military service there are frequently great changes in the sensitivities of roentgen films and screens. Temperature through a long range has little effect on the sensitivity of films exposed to roentgen rays

direct without the use of an intensifying screen. —*Audrey G. Morgan.*

HENSHAW, PAUL S. Influence of irradiation-killed cells on tumor growth. *J. Natl. Cancer Inst.*, Dec., 1943, *4*, 305–307.

Three types of experiments were carried out to investigate the influence of irradiation-killed tumor cells of the behavior of viable tumor cells. In all cases, mouse sarcoma 37 was used in young Dilute Brown male mice. The tumors grow rapidly and kill the host animal in ten to twenty days. Roentgen doses of 5,000 r applied to the tumor pulp before inoculation prevents all tumor growth.

In the first experiment, the pulp material was irradiated with a dose of 5,000 r in twenty-five minutes, the factors being 200 kv., 20 ma., 25 cm. distance and 0.25 mm. Cu plus 0.55 mm. Al filter. Then a mixture was made of treated and nontreated pulp material in the following proportions: 25 per cent irradiated plus 75 per cent nonirradiated, 50 per cent irradiated plus 50 per cent nonirradiated, and 75 per cent irradiated plus 25 per cent nonirradiated. Ten inoculations were made with each type of mixture and tumors grew rapidly in all cases killing the animals in ten to twenty days.

In the second experiment 10 well established subcutaneous tumors, 4 to 5 mm. in diameter, were obtained. Irradiation-killed pulp was inoculated subcutaneously into the region immediately surrounding the growing tumor masses. Again the rate of growth was not impaired by the presence of nonviable tumor material and that death of the host animal occurred as normally in ten to twenty days.

In the third experiment, tumors growing in animals were exposed to 5,000 r in a tangential manner which causes complete regression in 85 to 95 per cent. Ten animals with tumors 10 to 15 mm. in diameter were irradiated and immediately following treatment 0.04 mg. of normal viable pulp was injected directly into the irradiated tumor masses. New tumors arose within the scarred areas in all cases.

The author concludes that so far as the material tested is concerned, irradiation-killed cells or their decomposition products exert no inhibitory influence on the growth potentiality of viable tumor cells.—*Harry Hauser.*

HENSHAW, PAUL S. Experimental roentgen injury. I. Effects on the tissues and blood of C3H mice produced with single small whole-body exposures. *J. Natl. Cancer Inst.*, April, 1944, *4*, 477–484.

This communication deals with the first of a series of experiments to determine the effect of roentgen irradiation on the animal organism as observed by changes in tissues and peripheral blood. A single dose of 50 r was administered to 39 C3H mice at a rate of 8 r per minute. The technical factors were 200 kv., 20 ma., 0.5 mm. Cu and 1.06 mm. Al filter, and 105.3 cm. distance. Blood counts were made and tissues fixed at 1, 2, 4, 8, 12 and 24 hours, and 2, 4, 7, 10 and 14 days after irradiation. During the experiment, 3 animals were examined each time a count was made and the same 3 animals were killed for tissues. Three control animals were killed at the beginning and 3 other controls at the end of the experiment. A slight leukocytosis developed in two to four hours, which was followed within eight to twelve hours by a mild but persisting leukopenia, mainly or entirely a lymphopenia. The early transient leukocytosis suggests an inflammatory response to tissue damage. The production of the sustained leukopenia suggests that the limits of the leukocyte reserve were exceeded. The lymph nodes exhibited a small amount of nuclear debris at two to four hours followed by a mild hyperplasia at eight to twelve hours with disappearance of the nuclear debris. The seminiferous tubules of the testis showed a reduction in spermatogonia and primary spermatocytes at one week and of secondary spermatocytes at two weeks. Regeneration took place and the tubules appeared normal again in four to six weeks. Other minor tissue changes were observed such as swelling of the intestinal mucosa with hydropic changes in the lining cells of the villi. The edema and acid staining of the cytoplasm disappeared in eight to twelve hours. All these tissue changes indicate that, for the dose of radiation applied, the time of response is determined largely by the cells or tissues concerned and that the responses take place to some extent independently of each other.

The article is well illustrated with excellent photomicrographs of the changes in the lymph nodes, testis and ileum.—*Harry Hauser.*

HENSHAW, PAUL S. Experimental roentgen injury. II. Changes produced with intermediate-range doses and a comparison of the rela-

tive susceptibility of different kinds of animals. *J. Natl. Cancer Inst.*, April, 1944, *4*, 485–501.

In this second of a series of experiments, the author deals with the effects produced by doses commonly used in therapy ranging from 50 to 400 r. The animals used were C3H mice, LAF_1 mice and guinea pigs. Doses of 50, 100, 200 and 400 r were applied to the whole body of these animals using the same technical factors as in Experiment 1. Studies of the peripheral blood indicated an early leukocytosis followed by a leukopenia in animals receiving 50, 100 and 200 r, and only a leukopenia in those receiving 400 r. Guinea pigs proved to be more sensitive than C3H and LAF_1 mice, and LAF_1 mice somewhat more resistant than C3H mice. Lymph nodes, spleen, bone marrow and testis studied microscopically showed greater degrees of destructive changes with the higher doses. Some of the animals receiving 400 r died within eight days of exposure.

In a general way, the tissue response consisted of a parenchymatous cell loss followed by a slow return to normal if the damage was not too severe. Loss of functional cells appeared to result both from destruction of primitive cells and from further maturation. Regeneration in each case started from primitive cell forms that had survived irradiation fatal to other cells. Some of the more primitive cells were able to withstand doses of radiation that were fatal to primary spermatocytes, in this respect contradicting the view generally held that the more primitive the cell type, the more vulnerable to irradiation. Leukocyte reserves appeared to prevent the peripheral blood picture from reflecting precisely the condition of the hematopoietic tissue when the dosage was slight. Idiosyncrasies in the animal types were sufficient to indicate the necessity of using homogeneous groups of animals in making critical studies. The problems of the organism following moderate doses of radiation appear to depend largely upon injury to the stem cells of regenerative tissues. The article is well illustrated with graphs depicting peripheral blood changes and photomicrographs of lymph nodes, bone marrow and testis showing different stages of destruction and regeneration.—*Harry Hauser.*

Henshaw, Paul S. Experimental roentgen injury. III. Tissue and cellular changes brought about with single massive doses of radiation. *J. Natl. Cancer Inst.*, April, 1944, *4*, 503–512.

In order to shorten the time of death of animals, massive single doses of 25,000 to 50,000 r were delivered to 10 C3H mice, 4 guinea pigs and 12 rabbits. Guinea pigs died from shock at the end of treatment (three hours), rabbits within three to six hours after treatment, and the mice within twenty-four to forty-eight hours. Symptoms of restlessness, labored respiration, cyanosis and spastic twitching and stupor appeared during exposure. There was no evidence of hemoconcentration in the animals which died within a few hours of exposure, probably because there was not sufficient time for reaction. The leukocyte count dropped to a third in the first hour and during the second hour to about a tenth. Widespread tissue destruction took place. Lymphoid tissue was completely disarranged, the only cells appearing sufficiently intact being large, swollen, pink-staining primitive type cells. The bone marrow was similarly affected, but the amount of actual cellular debris was not so marked. The testes showed extensive changes including cytoplasmic degeneration, nuclear darkening and extensive cell loss with only skeletons of tubules remaining. Other tissues involved included small intestine, skin, lungs, liver, kidneys, adrenals and nervous system. In order to determine the nature of the shock reaction the testes of rabbits were irradiated locally with 25,000 r in less than thirty minutes. Within thirty-six hours extensive necrosis was present in pulmonary tissues. Excellent photomicrographs demonstrating destructive changes in the tissues accompany the article.—*Harry Hauser.*

Henshaw, Paul S. Experimental roentgen injury. IV. Effects of repeated small doses of x-rays on blood picture, tissue morphology, and life span in mice. *J. Natl. Cancer Inst.*, April, 1944, *4*, 513–522.

Because various physiologic complications or diseases late in life may unsuspectingly result from exposure to ionizing radiations, experiments were carried out to determine the effect of small daily doses of roentgen rays on animals. C3H male mice were exposed to small daily doses of 5, 10, 15, 20 and 25 r. Two complete experiments were performed, the second being a duplicate of the first except that the treatments in the first were discontinued at the end of twelve weeks since this experiment was exploratory in character. There was a fall in

leukocytes over a twenty-four week period. In animals receiving 5 to 15 r the neutrophils showed little change from the controls, but in those receiving 25 r there was a gradual drop in the count. The lymphocytes were more readily affected by smaller doses and showed a drop earlier in the treatment period. Extensive parenchymatous tissue damage was seen in lymph nodes, spleen, bone marrow, and testis, the degree of which varied in a general way with the size of the daily dose. A shortening of the life span was noted, the amount of which varied directly with the daily dose.

In addition, a few animals receiving 15 to 20 r per treatment for twelve weeks only showed a hyperplastic marrow with a fairly large primitive type cell as the predominant type. This cell was also prominent in the hematopoietic organs, surrounding musculature, kidneys, liver, lungs and other organs. Because of the invasive character of this primitive type cell, it has been regarded as a form of leukemia. Since persisting high levels of leukocytes were not maintained in the peripheral blood, the type has been considered pseudoleukemia or aleukemic leukemia. Most of the cases occurred in the first experiments in which treatments were given for only twelve weeks and in which the animals were receiving 15 to 20 r per day.—*Harry Hauser.*

MACKEE, GEORGE M., CIPOLLARO, ANTHONY C., and MUTSCHELLER, ARTHUR. Shock-proof roentgen ray apparatus in dermatology. *Arch. Dermat. & Syph.*, Jan., 1943, *47*, 43–57.

The authors discuss a new shock-proof roentgen apparatus which they hold is safer and more flexible than the old types of apparatus. It differs from the older machines chiefly in the fact that the connecting cables and tube housing are insulated so that they cannot give an electric shock. The tube is surrounded by a metal enclosure with a window transparent to roentgen rays. The space between the metal casing and the tube is filled with oil for which a cooling device is provided. A diagram of the apparatus is given. Measurements of the quality of the rays from the shock-proof and ordinary apparatus showed that they were practically the same so that the number of roentgens necessary to produce an erythema dose is about the same.

One disadvantage of the shock-proof apparatus is that the distribution of the radiation is not uniform so that it is not safe to use overlapping. To overcome this difficulty it is recommended that the window in the tube housing should be concentric with the oil-immersed tube so that the thickness of oil is uniform in all directions and that the oil-immersed tubes should have targets at an angle of 45 degrees with a round focus as in universal Coolidge tubes. The angle in the shock-proof apparatus has heretofore been 20 to 30 degrees.

In the discussion Dr. Andrews called attention to the fact that shock-proof apparatus is not necessary for safety and that even with it care is necessary. A number of technical details were discussed.—*Audrey G. Morgan.*

SUBJECT INDEX TO VOLUME 55

(abs) = abstracts (E) = editorial

Abdominal aorta, aneurysm of (abs), 119
aorta, retrograde aortography in study of, 448
lymphogranulomatosis, 165
Abscess, lung, secondary to stenosing bronchiogenic carcinoma (abs), 365
perinephric, previously unreported complication of amebiasis (abs), 121 total subphrenic (abs), 119
Absence, congenital, of lung diagnosed before death (abs), 364
Absorption, energy (abs), 375
Achalasia of cardia, carcinoma of esophagus in association with (abs), 109
Acromioclavicular joint, arthritis of (abs), 515
Adenoma of bronchus (abs), 365
of trachea and bronchus (abs), 109
Aerotitis and its prevention of use of radium (E), 483
Agenesis of lung in infant (abs), 114
Ainhum (abs), 237
Air and barium, visualization of biliary tract with, following barium meal (abs), 372
pressure, intrapulmonary, and its relation to pulmonary capillary flow, 575
Allison, Robert Glenn 1887–1946, obituary, 653
portrait, 653
Amebiasis of colon, roentgen diagnosis of (abs), 371
perinephric abscess a previously unreported complication of (abs), 121
Amebic epatitis, roentgen appearances in (abs), 118
American Board of Radiology, notice of examination, 349, 494, 778
College of Physicians, 99
Radium Society, notice of 1946 meeting of, 494
Radium Society, program of 1946 meeting of, 657
Roentgen Ray Society, announcement of 1946 meeting of, 658
Roentgen Ray Society, officers for year 1945–1946, 349
Anatomical variations of jugular fossa, 333
Aneurysm, cardiac (abs), 366
of abdominal aorta, 448
of abdominal aorta, rupture into jejunum preceded by occult blood in stool (abs), 119
Aneurysmal dilatation, congenital, of aorta associated with arachnodactyly (abs), 112
Ankle, diagnostic problems in fractures of, 594
Anomalies of gastrointestinal tract, relation of coincident, and renal ptosis to digestive disturbance (abs), 370
Aorta, arch of, and cardiac mensuration (abs), 363
congenital aneurysmal dilatation of, associated with arachnodactyly (abs), 112
Aortography, retrograde abdominal, 448
Apophyseal processes, intervertebral, roentgenology of (abs), 515
Apparatus for utilization of weak radon tubes, 101
shock-proof roentgen-ray, in dermatology (abs), 794
Arachnodactyly, congenital aneurysmal dilatation of aorta associated with (abs), 112
Area factor in roentgen irradiation (abs), 791
Army General Hospital, roentgen detection in an, of chronic diseases not excluded by induction board (abs), 524
Arthritis of acromioclavicular joint (abs), 515
Astragalus, fractures of external tuberosity of (abs), 237
Atomic bombing of Nagasaki, distribution of radiation in, 525
Atresia, congenital, of duodenum and of ileum (abs), 121
congenital, of pancreatic duct system as cause of meconium ileus (abs), 120
Auricle, left, quantitative roentgenographic method for determination of size of, 427
Australia, development of centralized radon services in (abs), 670
Avidin, treatment of cancer with (abs), 239

Bacterial pneumonia, primary atypical and, comparative roentgen study (abs), 364
Baker's cyst (abs), 236
Banti's syndrome, polycythemia secondary to (abs), 522
Barium enema examination of patient with colostomy, 782
-gelatine mixture for roentgen examination of digestive tract (abs), 368
meal, visualization of biliary tract with air and barium following (abs), 372
Basilar impression (abs), 787
Basophilism, pituitary, effect of various agents on calcium, phosphorus and nitrogen excretion in patient with (abs), 786
Belgium, need for radiological literature in, 348
Biliary tract, visualization of, with air and barium following barium meal (abs), 372
Bladder, cancer, skeletal and pulmonary metastases from, 153
carcinoma, treatment by supervoltage radiation, 533
Blood dyscrasias, hemothorax in (abs), 112
of C_3H mice, effects of, produced with single small whole-body exposures (abs), 792
picture in mice, effects of repeated small doses of roentgen rays on (abs), 793
Body section roentgenography (abs), 238
whole, integral dose when irradiated (abs), 375
Bone angle, projected, influence of position on measurement of, 722
changes, monocytic leukemia associated with (abs), 519

degeneration of temporomandibular joint (abs) 107
lesions in malignant lymphogranulomatosis (abs), 518
lesions, lymphosarcomatosis with (abs), 234
lymphogranulomatosis of (abs), 234
salts, metabolism of, in resistant rickets (abs), 235
BONES, long, chronic hypertrophy of skin and, an osteodermopathic syndrome (abs), 123
BOOK REVIEWS
Neuro-Ophthalmology. By Donald J. Lyle, 220
Escleróses Valvulares Calcificades. By Roberto Menezes de Oliveria, 220
A Bibliography of Aviation Medicine: Supplement. By Phebe Margaret Hoff, Ebbe Curtis Hoff and John Farquhar Fulton, 221
Consolidated Indices, Volume II. Author and Subject: 1938–1942, of the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY, 503
The Osseous System. A Handbook of Roentgen Diagnosis. By Vincent W. Archer, 503
Selected Papers from the Royal Cancer Hospital (Free) and the Chester Beatty Research Institute. Volume II. 1939–1940. Volume III. 1941–1942, 503
Nutrition and Chemical Growth in Childhood. Volume II. Original Data. By Icie G. Macy, 504
The History of Surgical Anesthesia. By Thomas E. Keys, 505
Classic Descriptions of Disease. Third edition. By Ralph H. Major, 661
A Textbook of Surgery. Sixth edition. By John Homans, 662
A Bibliography of Visual Literature 1939–1944. By John F. Fulton, Phebe M. Hoff, and Henrietta T. Perkins, 662
BOSTON MEDICAL HISTORY CLUB, 100
BRAIN, injuries of paracentral lobules of (abs), 785
midline and subtentorial tumors of, use of laminagraphy with encephalography in diagnosis of, 675
BREAST, cancer, radiosurgical treatment of (abs), 242
cancer, results of roentgen treatment of (abs), 243
cancer, roentgen irradiation of (abs), 242
cancer, treatment and results (abs), 240; (abs), 241; (abs), 242
tumors, castration in radiation treatment of (abs), 243
BRONCHIECTASIS, lower lobe, associated with tuberculosis (abs), 116
BRONCHIOGENIC carcinoma, roentgen diagnosis of (abs), 110
carcinoma, stenosing, lung abscess secondary to (abs), 365
BRONCHOGRAMS, improved technique for, 356
BRONCHOGRAPHY in pulmonary tuberculosis (abs), 115
BRONCHUS, adenoma of (abs), 109; (abs), 365
BRYAN, LLOYD 1884–1945, obituary, 488
portrait, 488
BULLITT, JAMES BELL 1863–1946, obituary, 651
portrait, 651

CALCAREOUS pancreatitis (abs), 120
CALCIFICATION, massive, of liver, 189
CALCIFIED spinal meningioma (abs), 511
CALCULATION of dose from point and linear sources of radium, 203
CALCULI, unusual urinary, 181
urinary tract, two unusual cases of (abs), 122
CALCULUS, salivary, or tartar (abs), 108
CANCER, advanced, neurosurgery and radiation for relief of pain (abs), 672
of bladder, skeletal and pulmonary metastases from, 153
of breast, castration in radiation treatment of (abs), 243
of breast, radiosurgical treatment (abs), 242
of breast, results of roentgen treatment of (abs), 243
of breast, roentgen irradiation of (abs), 242
of breast, treatment and results (abs), 240; (abs), 241; (abs), 242
of kidney, skeletal and pulmonary metastases from, 153
of lip (abs), 245
of prostate, skeletal and pulmonary metastases from, 153
of rectum (abs), 674
problem, place of National Cancer Institute in (abs), 249
Teaching Day, 219
treatment of, with avidin (abs), 239
CANNON, WALTER BRADFORD 1871–1945, obituary, 94
portrait, 94
CAPILLARY flow, pulmonary intrapulmonary air pressure and its relation to, 575
CARBON TETRACHLORIDE poisoning, pulmonary changes in, 16
CARCINOMA, bronchiogenic, roentgen diagnosis (abs), 110
of bladder, treatment by supervoltage radiation, 533
of cervix, treatment by supervoltage radiation, 533
of colon and rectum, clinical features, diagnosis and treatment (abs), 246
of esophagus in association with achalasia of cardia (abs), 109
of esophagus, supervoltage roentgen therapy of (abs), 671
of esophagus, treatment by supervoltage radiation, 533
of gastrointestinal tract, treatment by supervoltage radiation, 533
of kidneys, treatment by supervoltage radiation, 533

of larynx, treatment by supervoltage radiation, 533
of lung, intracranial metastasis of (abs), 106
of lung, treatment by supervoltage radiation, 533
of lung, treatment of (abs), 244
of nasopharynx (abs), 107
of nasopharynx, treatment by supervoltage radiation, 533
of oral cavity, treatment by supervoltage radiation, 533
of ovary, treatment by supervoltage radiation, 533
of prostate gland, treatment by supervoltage radiation, 533
of rectum, results of treatment of 173 cases (abs), 246
of rectum, treatment by supervoltage radiation, 533
of stomach, correlation of gastroscopic, roentgenologic and pathologic findings in, 251
of stomach, treatment by supervoltage radiation, 533
of testicle, treatment by supervoltage radiation, 533
of tongue, treatment by supervoltage radiation, 533
of tonsil, treatment by supervoltage radiation, 533
of uterus, treatment by supervoltage radiation, 533
stenosing bronchiogenic, lung abscess secondary to (abs), 365
Cardia, carcinoma of esophagus in association with achalasia of (abs), 109
of stomach, diverticulum of, 730
Castration for advanced malignant growth (abs), 673
in radiation treatment of tumors of breast (abs), 243
Cells, irradiation-killed, influence of, on tumor growth (abs), 792
Cellular changes brought about with single massive doses of radiation (abs), 793
Cephalhematomata, causation and characteristics of (abs), 105
Cerebellum, extradural hematoma of (abs), 787
medulloblastoma of (abs), 787
Chair for vertical encephalography, 779
Chest, fungus disease of (abs), 362
statistical analysis of 100,000 examinations of, by photoroentgen method (abs), 361
Childhood hypothyroidism, radioactive iodine studies in (abs), 111
postoperative pulmonary collapse in (abs), 113
Children between two and fourteen years, prevalence of rickets in (abs), 236
Cholecystography, oral, comparative study of single and divided dose method with contrast media in liquid and solid form (abs), 117
pheniodol as medium for (abs), 117
priodax as contrast medium in (abs), 117
with priodax, report on 600 examinations (abs), 118
Circulation, pulmonary, dynamics of, 575
Cleidocranial dysostosis, hereditary (abs), 512
Clinical characteristics of leukemia, 387
Clubbed fingers, 325
Coagulogram as critical indicator of irradiation effect, 464
Coccidioidomycosis, chronic pulmonary, roentgen study of, 396
Cocoanut Grove disaster, roentgen findings in lungs of victims of, 1, 494
Colon, carcinoma, clinical features, diagnosis and treatment (abs), 246
duplex, 319
roentgen diagnosis of amebiasis of (abs), 371
Colostomy, method for barium enema examination of patient with, 782
Congenital absence of lung diagnosed before death (abs), 364
absence of pedicle from cervical vertebra, 193
aneurysmal dilatation of aorta associated with arachnodactyly (abs), 112
atresia of duodenum and of ileum (abs), 121
atresia of pancreatic duct system as cause of meconium ileus (abs), 120
dislocation of hip, 331
duodenal diaphragm, megaduodenum secondary to, 726
obstruction, omphalocele with (abs), 119
Congrès (IVe) des Médecins Electro-Radiologistes de Langue Française, notice of meeting, 494
Contact radiation therapy, low voltage (abs), 240
Contrast and intensity distribution function of roentgen image, 67
media for roentgen diagnosis, iodinated organic compounds as (abs), 511
Corpus callosum, lipoma of, 125
Craniolacunia, origin of (abs), 105
Cushing's syndrome, therapeutic observations in (abs), 786
Cyst, Baker's (abs), 236
intracranial dural (abs), 787

David Anderson-Berry prize, 349
Dermatology, shock-proof roentgen-ray apparatus in (abs), 794
Diaphragm, hernia of (abs), 119
intrinsic duodenal, megaduodenum secondary to, 726
Diaphysis of humerus, fractures of (abs), 513
Digestive disturbance, relation of coincident anomalies of gastrointestinal tract and renal ptosis to (abs), 370
tract. See also Gastrointestinal tract
tract, barium-gelatine mixture for roentgen examination of (abs), 368
Diseases, chronic, roentgen detection of, in an

Army General Hospital, not excluded by induction boards (abs), 524
DISLOCATION, congenital, of hip, 331
DISPLAY case, portable, 231
DISTINCTOR, universal, of Holzknecht-Ingber in examination of gastrointestinal tract, 350
DIVERTICULUM, esophageal, esophagobronchial fistula through, 20
Meckel's (abs), 119
of cardia of stomach, 730
true pericardial, 27
DOSAGE, radium, nomographic aids in calculating, for plane and point sources (abs), 376
system for linear gamma-ray sources (abs), 376
DOSE, calculation of, from point and linear sources of radium, 203
integral, when whole body is irradiated (abs), 375
measurements of depth dose for 100, 120 and 135 kv. roentgen rays (abs), 375
roentgen-ray, condenser ionization chambers for measurement of (abs), 374
volume, significance of (E), 91
DOSES, effects of repeated small roentgen-ray, on blood picture, tissue morphology, and life span in mice (abs), 793
of radiation, tissue and cellular changes brought about with single massive (abs), 793
roentgen, changes produced with intermediate-range, and comparison of relative susceptibility of different kinds of animals (abs), 792
DUCROQUET'S plaster cast, treatment of trochanteric fractures of femur in old people with (abs), 517
DUODENAL diaphragm, intrinsic, megaduodenum secondary to, 726
DUODENUM, congenital atresia of (abs), 121
DUPLICATION of entire large intestine, 319
DURA, intracranial cyst of (abs), 787
DYSCRASIAS, blood, hemothorax in (abs), 112
DYSPITUITARISM as probable cause of chronic pulmonary osteoarthropathy (abs), 520

ECHINOCOCCUS CYST, lung lesions simulating pathognomonic roentgen sign of (abs), 117
EDEMA, presternal, mumps with (abs), 111
EDITORIALS
The significance of the volume dose, 91
Walter Bradford Cannon 1871–1945, 94
Tumors and tumor metastases in their relation to trauma, 213
Pneumothorax in young adult males, 344
Aerotitis and its prevention by the use of radium, 483
Lloyd Bryan 1884–1945, 488
Abraham Strauss 1887–1946, 490
The roentgenographic aspects of polycythemia vera, 649
James Bell Bullitt 1863–1946, 651
Robert Glenn Allison 1887–1946, 653
The problem of the most efficient therapeutic approach in mediastinal tumor, 766
Edwin Atkins Merritt 1880–1946, 769
Alexander Berkeley Moore 1883–1946, 771
Isaac Levin 1866–1945, 773
EFFECT, irradiation, coagulogram as critical indicator of, 464
of irradiation-killed cells on tumor growth (abs), 792
of irradiation of ovaries upon estrus and neoplastic diseases in Marsh-Buffalo mice (abs), 673
of roentgen therapy on experimental virus pneumonia, 473, 478
of temperature on sensitivities of roentgen-ray screens and films (abs), 791
on tissues and blood of C_3H mice produced with single small whole-body exposures of roentgen rays (abs), 792
EFFECTS, histologic, of radiophosphorus on normal and lymphomatous mice, 44
of radioactive sodium on normal and leukemic mice, 55
radiation, newer investigations of, and their clinical applications, 135
EGG WHITE, treatment of cancer with (abs), 239
EHLERS-DANLOS SYNDROME, 420
ELBOW, hemangioma of, successfully treated with radium at early age (abs), 246
EMPHYSEMA, spontaneous mediastinal (abs), 366
EMPHYSEMATOUS gastritis, 588
ENCEPHALOGRAPHY, use of laminagraphy with, in diagnosis of midline and subtentorial brain tumors, 675
vertical, chair for, 779
ENDOCRINE disturbances, roentgen therapy of, 337
ENDOTHELIOMA, primary, of pleura, 173
ENERGY absorption (abs), 375
EPIPHYSIS of terminal phalanx of a finger, osteochondritis of (abs), 513
ESOPHAGOBRONCHIAL fistula through an esophageal diverticulum, 20
ESOPHAGOCECAL fistula diagnosed roentgenologically (abs), 362
ESOPHAGUS, carcinoma, in association with achalasia of cardia (abs), 109
carcinoma, supervoltage roentgen therapy of (abs), 671
carcinoma, treatment by supervoltage radiation, 533
diverticulum of, esophagobronchial fistula through, 20
ESTRUS, influence of irradiation of ovaries upon, in Marsh-Buffalo mice (abs), 673
ETHYL IODOPHENYLUNDECYLATE, experimental and clinical myelography with (abs), 511
EYE and radiology (abs), 106
physiology of (abs), 106
EYES, device for preparation of, for roentgenoscopy, 348

Femur, treatment of trochanteric fractures of, in old people with Ducroquet's plaster cast (abs), 517
Fibroma, ossifying, of superior maxilla (abs), 788
Film contrast factor, 627
identification marker, custom made, 664
Filters, wedge, use of, in deep roentgen therapy (abs), 249
Finger, osteochrondritis of epiphysis of terminal phalanx of (abs), 513
Fingers, clubbed, 325
Fistula, esophagobronchial, through esophageal diverticulum, 20
esophagocecal, diagnosed roentgenologically (abs), 362
Florida Radiological Society, 778
Foot, diagnostic problems in fractures of, 594
march fracture of, and in other bones (abs), 517
Fossa, giant jugular, 333
Fracture, fissure, occasional appearance of inner and outer suture lines in roentgenograms of skull simulating, 315
isolated, of first rib produced by muscular traction (abs), 512
Fractures, compression, of vertebral bodies, and other changes mistaken for them (abs), 514
delayed reduction of (abs), 516
march (abs), 517
march, including others than those of foot (abs), 517
of diaphysis of humerus (abs), 513
of external tuberosity of astragalus (abs), 237
of foot and ankle, diagnostic problems of, 594
trochanteric, treatment of, of femur, in old people with Ducroquet's plaster cast (abs), 517
French radiologists, recent visit with, 634
Friedman, Major Milton, M.C., honored, 494
Fungus disease of chest (abs), 362

Gamma-ray sources, linear, dosage system for (abs), 376
Ganglia of wrist, radiation treatment of (abs), 674
Gangrene of skin from migratory and dissecting postoperative hematoma (abs), 523
Gastritis, correlation of gastroscopic, roentgenologic and pathologic findings in, 251
emphysematous, 588
Gastrointestinal tract, carcinoma, treatment by supervoltage radiation, 533
relation of coincident anomalies of, and renal ptosis to digestive disturbance (abs), 370
universal distinctor of Holzknecht-Ingber in examination of, 350
Gastroscopic, correlation of, with roentgenologic and pathologic findings in diseases of stomach, 251
Giant cell of giant cell tumors, morphology, histogenesis and biology of (abs), 518

Heart, quantitative roentgenographic method for determination of size of left auricle, 427
simple method of measurement of (abs), 363
Heat capacities of roentgen-ray tubes, 621
Hemangioma of elbow successfully treated with radium at early age (abs), 246
Hematogenous muscle tuberculosis (abs), 238
Hematological characteristics of leukemia, 387
Hematoma, extradural cerebellar (abs), 787
migratory and dissecting postoperative, gangrene of skin from (abs), 523
Hemothorax in blood dyscrasias (abs), 112
Hepatitis, amebic, roentgen appearances in (abs), 118
Hernia, diaphragmatic (abs), 119
traumatic, of lateral pharyngeal walls (abs), 361
Herniation, posterior, of knee joint (abs), 236
Hip, congenital dislocation of, 331
Histologic effects of radiophosphorus on normal and lymphomatous mice, 44
Histoplasmosis (abs), 238
Hodgkin's disease. See also Lymphogranulomatosis, malignant sarcoma type, lymphoblastoma of (abs), 521
Holzknecht-Ingber, universal distinctor of, in examination of gastrointestinal tract, 350
Hospital personnel, tuberculosis among (abs), 114
Humerus, fractures of diaphysis of (abs), 513
osteochondritis dissecans of supratrochlear septum of, 717
Hydatid disease, alveolar, as possible cause of massive calcification of liver, 189
Hyperostosis, internal frontal, syndrome of (abs), 360
Hypertension, essential and malignant, pyelograms in patients with (abs), 122
Hyperthyroidism, roentgen therapy of, 337
Hypertrophy, chronic, of skin and long bones, an osteodermopathic syndrome (abs), 123
Hypothyroidism, childhood, radioactive iodine studies in (abs), 111

Ileum, congenital atresia of (abs), 121
Induction station, procedures facilitating roentgenologic interpretation in, 617
Industrial radiation hazards (abs), 789
Infant, agenesis of lung in (abs), 114
Infants, osteomyelitis in, 299
roentgen diagnosis of hypertrophic pyloric stenosis in (abs), 370
Infections, suppurative, roentgen therapy with low dosage in (abs), 247
Inflammatory conditions, theories on effectiveness of roentgen therapy in (abs), 247
Influenza virus, swine, pneumonia produced in white mice by, effect of roentgen therapy, 478
Injuries of vertex of skull (abs), 785
Injury, experimental roentgen (abs), 792; (abs), 793
Intensity distribution function of roentgen image, 67

INTER-AMERICAN CONGRESS OF RADIOLOGY, Second, preliminary program, 217
INTERVERTEBRAL apophyseal processes, roentgenology of (abs), 515
discs, nature and function of (abs), 124
INTESTINE, large, duplication of, 319
small, correlation of roentgen diagnosis with operative findings in obstruction of (abs), 371
INTRABRONCHIAL spread following thoracoplasty (abs), 110
INTRACRANIAL metastasis of carcinoma of lung (abs), 106
IODINATED organic compounds as contrast media for roentgen diagnosis (abs), 511; (abs), 512
IODINE, radioactive, studies in childhood hypothyroidism (abs), 111
IONIZATION chambers, condenser, for measurement of roentgen-ray dose (abs), 374
IRRADIATION effect, coagulogram as critical indicator of, 464
killed cells, influence of, on tumor growth (abs), 792
of ovaries, influence of, upon estrus and neoplastic development in Marsh-Buffalo mice (abs), 673
of whole body, integral dose (abs), 375
pelvic, ureter and its involvement in (abs), 672
pneumonitis (abs), 368
roentgen, area factor in (abs), 791
sickness (abs), 239
single small doses, whole-body, effects on tissues and blood of C_3H mice of (abs), 792
time factor in (abs), 790

JAW, upper, malignant tumors of (abs), 107
JUGULAR FOSSA, giant, 333

KIDNEYS, cancer, skeletal and pulmonary metastases from, 153
carcinoma, treatment by supervoltage radiation, 533
malignant tumors of (abs), 374
relation of coincident anomalies of gastrointestinal tract and ptosis of, to digestive disturbance (abs), 370
tumors of (abs), 373
KNEE JOINT, pneumoroentgenography of (abs), 237
posterior herniation of (abs), 236

LAMINAGRAPHIC attachment for United States Army field roentgen-ray unit, 667
LAMINAGRAPHY with encephalography in diagnosis of midline and subtentorial brain tumors, 675
LARYNX, carcinoma, treatment by supervoltage radiation, 533
LEGG-PERTHES DISEASE, relation of, to function of thyroid gland (abs), 515
LEONTIASIS OSSEA, generalized, 37
LEUKEMIA, hematological and clinical characteristics of, 387
in mice following exposure to roentgen rays (abs), 789
in physicians, incidence of (abs), 790
in radiologists (abs), 790
monocytic, associated with bone changes (abs), 519
roentgen treatment of, 377
LEUKEMIC mice, effects of radioactive sodium and of roentgen rays on, 55
LEUKOSARCOMA, 743
LEVIN, ISAAC 1866–1945, obituary, 773
portrait, 773
LIFE span in mice, effects of repeated small doses of roentgen rays on (abs), 793
LIP, cancer of (abs), 245
LIPOMA of corpus callosum, 125
LIVER, massive calcification of, 189
LUMBOSACRAL region, roentgenograms of, in 100 soldiers, 292
LUNG abscess secondary to stenosing bronchiogenic carcinoma (abs), 365
agenesis of, in infant (abs), 114
congenital absence of, diagnosed before death (abs), 364
tumor in superior sulcus of (abs), 113
LUNGS, anteroposterior lordotic projection in roentgen examination of (abs), 361
capillary flow in, intrapulmonary air pressure and its relation to, 575
carcinoma, treatment by supervoltage radiation, 533
carcinoma, treatment of (abs), 244
changes in, in carbon tetrachloride poisoning, 16
chronic osteoarthropathy of (abs), 520
clinical and roentgen studies in mycosis of (abs), 362
fungus disease of (abs), 362
intracranial metastasis of carcinoma of (abs), 106
lesions of, simulating pathognomonic roentgen sign of echinococcus cyst (abs), 117
metastases, from cancer of kidney, prostate and bladder, 153
of victims of Cocoanut Grove disaster, roentgen findings in, 1, 494
postoperative collapse of, in childhood (abs), 113
LYMPH NODES, obstructing tuberculous hilar, radiation therapy for (abs), 247
LYMPHOBLASTOMA of Hodgkin's sarcoma type (abs), 521
LYMPHOGRANULOMATOSIS, abdominal, 165
malignant, with bone lesions (abs), 518
of bone (abs), 234
LYMPHOID TISSUE, in nasopharynx and pharynx, radiation therapy of (abs), 671
in nasopharynx, roentgen treatment of (abs), 672
LYMPHOMA of stomach, correlation of gastroscopic, roentgenologic and pathologic findings in, 251

treatment by supervoltage radiation, 533
Lymphomatous mice, histologic effects of radiophosphorus on, 44
Lymphosarcomatosis with bone lesions (abs), 234

Mandible, osteoradionecrosis of, 733
Maxilla, superior, ossifying fibroma of (abs), 788
Maxillary sinuses, tomography in region of (abs), 360
Measurement, depth dose, for 100, 120 and 135 kv. roentgen rays (abs), 375
method of, for determination of left auricular size, 427
of projected bone angle, influence of position on, 722
of roentgen-ray dose, condenser ionization chambers for (abs), 374
Meckel's diverticulum (abs), 119
Meconium ileus, congenital atresia of pancreatic duct system as cause of (abs), 120
Mediastinum, problem of most efficient therapeutic approach in tumors of (E), 766
spontaneous emphysema of (abs), 366
tumors, roentgenologic features of (abs), 367
Medical papers, comments on preparation and presentation of, 495
Medulloblastoma, cerebellar (abs), 787
Megacolon (abs), 121
Megaduodenum secondary to intrinsic duodenal diaphragm, 726
Meningioma, calcified spinal (abs), 511
Meningocele, frontal, otolaryngologic aspect of (abs), 785
Mensuration, cardiac (abs), 363
Merritt, Edwin Atkins 1880–1946, obituary, 769
portrait, 769
Mesothelioma, primary, of pleura, 173
Metabolism of bone salts in resistant rickets (abs), 235
Metastases, skeletal and pulmonary, from cancer of kidney, prostate and bladder, 153
tumor, in their relation to trauma (E), 213
Metastasis, intracranial, of carcinoma of lung (abs), 106
Mice, C_3H, effects on tissues and blood of, produced with single small whole-body exposures (abs), 792
effects of repeated small doses of roentgen rays on blood picture, tissue morphology and life span in (abs), 793
leukemia in, following exposure to roentgen rays (abs), 789
Marsh-Buffalo, influence of irradiation of ovaries upon estrus and neoplastic development in (abs), 673
normal and leukemic, effects of radiactive sodium on, 55
normal and lymphomatous, histologic effects of radiophosphorus on, 44
Miliary densities associated with mitral stenosis (abs), 111
Mitral stenosis, miliary densities associated with (abs), 111
Moore, Alexander Berkeley 1883–1946, obituary, 771
portrait, 771
Morgagni-Stewart-Morel syndrome, pneumoencephalographic findings in (abs), 786
Mumps with presternal edema (abs), 111
Muscle tuberculosis, hematogenous (abs), 238
Muscular traction, isolated fracture of first rib produced by (abs), 512
Mycosis, pulmonary, clinical and roentgen studies in (abs), 362
Myelographic diagnosis of extramedullary cervical spinal cord tumors, 413
Myelography, experimental and clinical, with pantopaque (abs), 511
opaque, in penetrating wounds of spinal canal, 689
pantopaque (abs), 512
with pantopaque, and new technique for its removal (abs), 511

Nagasaki, distribution of radiation in atomic bombing of, 525
Nasopharynx, carcinoma of (abs), 107
carcinoma of, treatment by supervoltage radiation, 533
radiation therapy of lymphoid tissue in (abs), 671
roentgen treatment of lymphoid tissue in (abs), 672
National Cancer Institute, place of, in cancer problem (abs), 249
Navy recruits, pulmonary tuberculosis in (abs), 115
Necrosis, pancreatic, roentgen aspects of (abs), 372
Neoplasm. See Tumor
Neurogenic polycythemia (abs), 523
Neurologic changes, unusual osseous disease with (abs), 123
Neurosurgery and radiation for relief of pain in advanced cancer (abs), 672
New England Roentgen Ray Society, 658
Nomogram as aid in calculating radium dosage for plane and point sources (abs), 376
North Carolina Radiological Society, program of annual meeting, 348

Obstruction, small intestinal, correlation of roentgen diagnosis with operative findings in (abs), 371
Omphalocele with congenital obstruction (abs), 119
Oral cavity, carcinoma, treatment by supervoltage radiation, 533
Organic compounds, iodinated, as contrast media for roentgen diagnosis (abs), 511; (abs), 512
Orleans Parish Radiological Society, 494
Orthodiagrams, simplified method for making, 508
Osseous disease, unusual, with neurologic changes (abs), 123

Osteitis fibrosa and renal osteomalacia in adults (abs), 235
focal, of skull (abs). 235
Osteoarthritis of spine, 292
Osteoarthropathy, chronic pulmonary (abs), 520
Osteochondritis of epiphysis of terminal phalanx of a finger (abs), 513
dissecans of supratrochlear septum of humerus, 717
Osteoclastoma, diagnosis and treatment (abs), 520
Osteodermopathic syndrome (abs), 123
Osteogenesis imperfecta, rickets and infantile scurvy in case of, 30
Osteogenic sarcoma, treatment of, with preoperative roentgen radiation in large doses (abs), 244
Osteoid osteoma (abs), 519
Osteomalacia, renal, and osteitis fibrosa in adults (abs), 235
Osteomyelitis in infants, 299
Osteoradionecrosis of mandible, 733
Otolaryngologic aspect of frontal meningocele (abs), 785
Ovaries, carcinoma, treatment by supervoltage radiation, 533
influence of irradiation of, upon estrus and neoplastic development in Marsh-Buffalo mice (abs), 673

Paget's disease, basilar impression secondary to (abs), 787
Pain, neurosurgery and radiation for relief of, in advanced cancer (abs), 672
Palindromic rheumatism (abs), 519
Pancoast Lecture, 1942, 135; 1944, 251
Pancreas, roentgen aspects of necrosis of (abs), 372
Pancreatic duct system, congenital atresia of, as cause of meconium ileus (abs), 120
Pancreatitis, calcareous (abs), 120
Pantopaque, experimental and clinical myelography with (abs), 511
myelography (abs), 512
myelography with, and new technique for its removal (abs), 511
use of, in myelographic diagnosis of extramedullary cervical spinal cord tumors, 413
Papers, medical, comments on preparation and presentation of, 495
Pathologic, correlation, with gastroscopic and roentgenologic findings in diseases of the stomach, 251
Pedicle, congenital absence of, from cervical vertebra, 193
Pelvis, involvement of ureter in irradiation of (abs), 672
Pennsylvania Radiological Society, notice of meeting, 494
program of meeting, 778
Peptic ulcer, correlation of gastroscopic, roentgenologic and pathologic findings in, 251
wartime, responsibility of roentgenologist in problem of (abs), 370
Pericardial diverticulum, true, 27
Phalanx, terminal, of finger, osteochondritis of (abs), 513
radiation therapy of lymphoid tissue in (abs), 671
traumatic hernia of lateral walls of (abs), 361
Pheniodol as medium for cholecystography (abs), 117
Photofluorographic personnel, protection of, 198
Photoroentgen method, statistical analysis of 100,000 examinations of chest by (abs), 361
Physical factors, controlling diagnostic quality of roentgen images, analysis of 67, 627
Physicians, leukemia in, incidence of (abs), 790
Platybasia (abs), 787
Pleura, primary mesothelioma of, 173
Pneumocephalus, traumatic (abs), 787
Pneumoencephalographic findings in Morgagni-Stewart-Morel syndrome (abs), 786
Pneumography, subdural, 710
Pneumonia, experimental virus, effect of roentgen therapy on, 473
feline virus, effect of roentgen therapy on, 473
primary atypical and bacterial, comparative roentgen study (abs), 364
primary atypical, roentgen diagnosis (abs), 364
primary atypical virus, roentgen study (abs), 363
produced in white mice by swine influenza virus, effect of roentgen therapy on, 478
Pneumonitis, irradiation (abs), 368
persistent coccidioidal, 396
Pneumoperitoneum, diagnostic value of (abs), 369
postoperative (abs), 113
Pneumoroentgenography of knee joint (abs), 237
Pneumothorax in young adult males (E), 344
Poisoning, carbon tetrachloride, pulmonary changes in, 16
Polycythemia and associated manifestations, satisfactory treatment of, with radiophosphorus (abs), 522
neurogenic (abs), 523
secondary possibly to Banti's syndrome (abs), 522
vera, roentgenographic aspects of (E), 649
Position, influence of, on measurement of projected bone angle, 722
Presternal edema, mumps with (abs), 111
Priodax as contrast medium in cholecystography (abs), 117
cholecystography with, report on 600 examinations (abs), 118
Prostate gland, cancer, skeletal and pulmonary metastases from, 153
carcinoma, treatment by supervoltage radiation, 533
Protection of photofluorographic personnel, 198

Pyelograms in patients with essential and malignant hypertension (abs), 122
Pyelography, value of delayed examination in (abs) 373
Pylorus, hypertrophic stenosis of, in infants, roentgen diagnosis (abs), 370

Quality, diagnostic, of roentgen images, physical factors controlling, 67, 627

Radiation and neurosurgery for relief of pain in advanced cancer (abs), 672
distribution of, in atomic bombing of Nagasaki 525
effects, newer investigations of, and their clinical applications, 135
hazards, industrial (abs), 789
supervoltage, review of cases treated during eighth period, 533
therapy for obstructing tuberculous hilarlymph nodes (abs), 247
therapy, low voltage contact (abs), 240
tissue and cellular changes brought about with single massive doses of (abs), 793
treatment of tumors of breast, castration in (abs), 243
Radioactive iodine studies in childhood hypothyroidism (abs), 111
sodium, effects of, on normal and leukemic mice, 55
Radiological literature, need for, in Belgium, 348
Radiologists, French, recent visit with, 634
leukemia in (abs), 790
Radiology and the eye (abs), 106
Section, California Medical Association, 778
Radiophosphorus, histologic effects of, on normal and lymphomatous mice, 44
satisfactory treatment of polycythemia and associated manifestations with (abs), 522
Radium, aerotitis and its prevention by use of (E), 483
dosage for plane and point sources, nomographic aids in calculating (abs), 376
point and linear sources of, calculation of dose from, 203
successful treatment of hemangioma of elbow at early age (abs), 246
treatment using rectangular teleradium fields (abs), 240
Radon services, centralized, development of, in Australia (abs), 670
tubes, weak, apparatus for utilization of, 101
Rectum, cancer of (abs), 674
carcinoma, clinical features, diagnosis and treatment (abs), 246
carcinoma, results of treatment of 173 cases (abs), 246
carcinoma, treatment by supervoltage radiation, 533
Renal osteomalacia and osteitis fibrosa in adults (abs), 235
Rheumatism, palindromic (abs), 519
Rib, first, isolated fracture of, produced by muscular traction (abs), 512
Rickets and infantile scurvy occurring in case of osteogenesis imperfecta, 30
prevalence of, in children between two and fourteen years (abs), 236
resistant, metabolism of bone salts in (abs), 235
Rocky Mountain Radiological Society, 658
Roentgen detection in an Army General Hospital of chronic diseases not excluded by induction boards (abs), 524
diagnosis, iodinated organic compounds as contrast media for (abs), 511; (abs), 512
examination of lungs, anteroposterior lordotic projection in (abs), 361
films, reciprocity law failures in (abs), 249
image, contrast and intensity distribution function of, 67
images, physical factors controlling diagnostic quality of, 67, 627
injury, experimental (abs), 792; (abs), 793
irradiation, area factor in (abs), 791
irradiation, time-intensity factor in (abs), 250
radiation and stilbestrol, regression of tumors following treatment by (abs), 243
-ray apparatus, shock-proof, in dermatology (abs), 794
ray, fiftieth anniversary of discovery of, observance of, in Rochester, N. Y., 658
-ray machine, demonstration "live" circuit-diagram model, 224
-ray screens and films, quantitative study of effect of temperature on sensitivities of (abs), 791
-ray technicians, training of, at School for Medical Department Enlisted Technicians (abs), 248
-ray tubes, heat capacities of, 621
-ray unit, United States Army field, laminagraphic attachment for, 667
rays, effect of, on normal and leukemic mice, 55
rays, leukemia in mice following exposure to (abs), 789
rays, 100, 120 and 135 kv., depth dose measurements for (abs), 375
technique, elements of, 350
therapy, deep, use of wedge filters in (abs), 249
therapy, effect of, on experimental virus pneumonia, 473, 478
therapy for malignant teratoma of testis, 754
therapy in inflammatory conditions, theories on effectiveness of (abs), 247
therapy of hyperthyroidism and related endocrine disturbances, 337
therapy of leukemia, 377
therapy, supervoltage, of esophageal carcinoma (abs), 671

therapy with low dosage in suppurative infections (abs), 247
ROENTGENOGRAMS, lumbosacral, of 100 soldiers, 292
ROENTGENOGRAPHIC method, quantitative, for determination of left auricular size, 427
ROENTGENOGRAPHY, body section (abs), 238
in supine position for diagnosis of lesions of corpus and posterior wall of stomach, 454
ROENTGENOLOGIC, correlation of, with gastroscopic and pathologic findings in diseases of stomach, 251
findings in lungs of victims of Cocoanut Grove disaster, 1, 494
interpretation in an induction station, procedures facilitating, 617
ROENTGENOLOGIST, responsibility of, in wartime duodenal ulcer problem (abs), 370
ROENTGENOLOGY of intervertebral apophyseal processes (abs), 515
ROENTGENOSCOPY, device for preparation of eyes for, 348
RÖNTGEN, memoirs of student in laboratory of, in Würzburg half a century ago, 643

SALIVARY calculus or tartar (abs), 108
glands, tumors, diagnosis, classification and treatment (abs), 108
SARCOMA, Hodgkin's type, lymphoblastoma of (abs), 521
of stomach, correlation of gastroscopic, roentgenologic and pathologic findings in, 251
osteogenic, treatment of, with preoperative roentgen radiation in large doses (abs), 244
SCHOOL for Medical Department Enlisted Technicians, training of roentgen-ray technicians at (abs), 248
SCURVY, infantile, and rickets, occurring in case of osteogenesis imperfecta, 30
SHOULDER JOINT, primary malignant neoplasm of (abs), 521
SINUSES, maxillary, tomography in region of (abs), 360
SINUSITIS, roentgen therapy of, with special adapter (abs), 670
roentgen treatment of (abs), 670
SKELETAL metastases, from cancer of kidney, prostate and bladder, 153
SKIN, chronic hypertrophy of, and long bones, an osteodermopathic syndrome (abs), 123
gangrene of, from migratory and dissecting postoperative hematoma (abs), 523
SKULL, focal osteitis fibrosa of (abs), 235
injuries of vertex of (abs), 785
occasional appearance of inner and outer suture lines in roentgenograms of, simulating fissure fracture, 315
SOLDIERS, lumbosacral roentgenograms of one hundred, 292
SOVIET UNION, message from, 219
SPECULUM, transvaginal, improved (abs), 673
SPINA BIFIDA OCCULTA, 292
SPINAL canal, opaque myelography in penetrating wounds of, 689
cord tumors, extramedullary cervical, myelographic diagnosis of, 413
SPINE, calcified meningioma of (abs), 511
lumbosacral roentgenograms of 100 soldiers, 292
osteoarthritis of, 292
SPONDYLOLISTHESIS, 292
criteria for more accurate diagnosis of true anterior slip of involved vertebral segment, 275
SPONDYLOLYSIS, 292
STAB wound, unusual (abs), 360
STENOSIS, hypertrophic pyloric, in infants, roentgen diagnosis of (abs), 370
mitral, miliary densities associated with (abs), 111
STENSEN'S DUCT, primary tumors of (abs), 788
STEREOGRAPHY, instantaneous (abs), 249
STILBESTROL and roentgen therapy, regression of tumors following treatment by (abs), 243
STOMACH, carcinoma, treatment by supervoltage radiation, 533
corpus and posterior wall of, supine projection in diagnosis of lesions of, 454
correlation of gastroscopic, roentgenologic and pathologic findings in diseases of, 251
diverticulum of cardia of, 730
syphilis of (abs), 369
STRAUSS, ABRAHAM, 1887–1946, obituary, 490
portrait, 490
resolution passed by Cleveland Radiological Society on death of, 491
SUBDURAL pneumography, 710
SUBPHRENIC abscess, total (abs), 119
SULCUS, superior pulmonary, tumor in (abs), 113
SUPINE projection in diagnosis of lesions of corpus and posterior wall of stomach, 454
SUPPURATIVE infections, roentgen therapy with low dosage in (abs), 247
SUPRATROCHLEAR septum of humerus, osteochondritis dissecans of, 717
SUTURE lines, inner and outer, occasional appearance of, in roentgenograms of skull simulating fissure fracture, 315
SYPHILIS of stomach (abs), 369

TARTAR, or salivary calculus (abs), 108
TECHNICIANS, roentgen-ray, training of, at School for Medical Department Enlisted Technicians (abs), 248
TECHNIQUE, anteroposterior lordotic projection in roentgen examination of lungs (abs), 361
improved, for bronchograms, 356
new, for removal of pantopaque used in myelography (abs), 511
roentgen, elements of, 350
TELERADIUM fields, rectangular (abs), 240

Temperature, quantitative study of effect of, on sensitivities of roentgen-ray screens and films (abs), 791
Temporomandibular joint, bone degeneration of (abs), 107
Tennessee Radiological Society, 660
Teratoma, malignant, of testis, roentgen therapy for, 754
Testis, carcinoma, treatment by supervoltage radiation, 533
malignant teratoma, roentgen therapy for, 754
malignant tumors, management of, 555
Texas Radiological Society, 100
Thiouracil in treatment of hyperthyroidism, 337
Thoracoplasty, intrabronchial spread following (abs), 110
Thyroid gland, relation of Legg-Perthes disease to function of (abs), 515
Time factor in irradiation (abs), 790
-intensity factor in roentgen irradiation (abs), 250
Tissue changes brought about with single massive doses of radiation (abs), 793
morphology in mice, effects of repeated small doses of roentgen rays on (abs), 793
Tissues of C_3H mice, effects of, produced with single small whole-body exposures (abs), 792
Tomography in region of maxillary sinuses (abs), 360
Tongue, carcinoma, treatment by supervoltage radiation, 533
Tonsil, carcinoma, treatment by supervoltage radiation, 533
Trachea, adenoma of (abs), 109
Trauma, tumors and tumor metastases in their relation to (E), 213
Traumatic hernia of lateral pharyngeal walls (abs), 361
Tuberculosis among hospital personnel (abs), 114
hematogenous muscle (abs), 238
lower lobe bronchiectasis associated with (abs), 116
pulmonary, accidentally discovered (abs), 116
pulmonary, bronchography in (abs), 115
pulmonary, in Navy recruits (abs), 115
pulmonary, intrabronchial spread following thoracoplasty (abs), 110
Tuberculous hilar lymph nodes, obstructing, radiation therapy for (abs), 247
Tuberosity, external, of astragalus, fractures of (abs), 237
Tumor, benign, of stomach, correlation of gastroscopic, roentgenologic and pathologic findings in, 251
development of, in Marsh-Buffalo mice, influence of irradiation of ovaries upon (abs), 673
growth, influence of irradiation-killed cells on (abs), 792
in superior pulmonary sulcus (abs), 113
mediastinal, problem of most efficient therapeutic approach in (E), 766
primary malignant, of shoulder joint (abs), 521
Tumors, advanced malignant, castration for (abs), 673
extramedullary cervical spinal cord, myelographic diagnosis of, 413
giant cell, morphology, histogenesis and biology of giant cell of (abs), 518
in their relation to trauma (E), 213
malignant, of kidney (abs), 374
malignant, of testis, management of, 555
malignant, of upper jaw (abs), 107
mediastinal, roentgenologic features of (abs), 367
midline and subtentorial brain, use of laminagraphy with encephalography in diagnosis of, 675
of kidney (abs), 373
of salivary glands, diagnosis, classification and treatment (abs), 108
primary, of Stensen's and Wharton's ducts (abs), 788
regression of, following treatment by stilbestrol and roentgen radiation (abs), 243

Ureter, involvement of, in pelvic irradiation (abs), 672
Urinary calculi, unusual, 181
tract calculi, two unusual cases of (abs), 122
Urology award, 219
Uterus, carcinoma, treatment by supervoltage radiation, 533
cervix, carcinoma, treatment by supervoltage radiation, 533

Venography, further experiences with (abs), 522
Ventriculograms in case of traumatic pneumocephalus (abs), 787
Vertebra, cervical, congenital absence of pedicle from, 193
Vertebral bodies, compression fractures of, and other changes mistaken for them (abs), 514
Viewing box and display case, portable, 231
Virus pneumonia, experimental, effect of roentgen therapy on, 473, 478
primary atypical, roentgen study (abs), 363

Wartime duodenal ulcer problem, responsibility of roentgenologist in (abs), 370
Watts Hospital Medical and Surgical Symposium, 99
Wharton's duct, primary tumors of (abs), 788
Wound, unusual stab (abs), 360
Wounds, penetrating, of spinal canal, opaque myelography in, 689
Wrist, radiation treatment of ganglia of (abs), 674

AUTHOR INDEX TO VOLUME 55

Abel, Martin S., 368
Abeles, Hans, 116
Alexander, Theodore O., 368
Altman, William S., 664
Anderson, W. A. D., 521
Archer, Vincent W., 503, 672
Arnett, John H., 511
Ashbury, Howard Hicks, 671
Atlee, Z. J., 621

Bachman, Arnold L., 427
Baer, Ridgely W., 112
Bailey, Orville T., 787
Baker, E. C., 522
Baker, Wallace P., 224
Bannen, J. E., 113
Barden, Stuart P., 122
Bassin, Sydney, 111
Baylin, G. J., 238, 372, 473, 478
Bean, William B., 239
Beilin, David S., 246
Bell, J. Sheridan, 508
Benedict, Edward B., 251
Bersack, S. R., 109
Bertin, E. J., 181
Bianchi, Andrés, 234
Binnie, George G., 243
Bischoff, Fritz, 673
Bixler, Louis C., 374
Borak, J., 247
Bobrowitz, I. D., 117
Bogart, Franklin B., 743
Boveri, Juan C., 523
Bradley, J. Edmund, 119
Braestrup, C. B., 375, 789
Brailsford, James F., 520
Brock, R. C., 244
Brocklebank, J. A., 235
Bromer, Ralph S., 30
Bromley, J. F., 106
Bryan, Lloyd, 117
Burnett, C. W. F., 105
Buschke, Franz, 671
Butler, Carlos, 240

Calthrop, G. T., 117
Canizares, Rafael, 241
Cantril, Simeon T., 671
Caprio, Gerardo, 242
Cardenas, L., 101
Carlson, Glenn D., 517
Carpenter, Gurth, 523
Carvalho, Nelson, 241
Chamberlain, Dorothy B., 120
Chamberlain, W. Edward, 393
Chamberlin, George W., 555
Charr, Robert, 325
Childress, William G., 114
Chiodin, Leopoldo, 518
Christensen, F. C., 670
Christie, Arthur C., 770, 772
Cifarelli, Francisco P., 243
Cipollaro, Anthony C., 790, 791, 794
Clarkson, J. R., 240, 375
Clement, Baxter L., 517
Cohen, Emanuel S., 726
Cohn, Elma T., 235
Cohn, Waldo E., 235
Colvin, S. H., Jr., 238
Cooper, George, Jr., 672
Cooper, William Grant, Jr., 119
Copleman, Benjamin, 361
Cotton, J. M., 779
Craver, Lloyd F., 165
Creevy, C. D., 374
Crevasse, J. N., 779

Dal Lago, Héctor, 515
Danelius, Gerhard, 315
Darling, A. Perry, 511
Davidoff, Leo M., 413, 675
Davidson, Charles S., 1
Deweese, E. R., 364
Diaz-Rivera, R. S., 121
Dixon, Claude F., 319
Dobbie, J. L., 244
Dooley, Samuel W., 114
Dormer, B. A., 115
Douglas, S. J., 245
Drucker, Victor, 726
Dubin, I. N., 473, 478
Dungan, Clarence E., 511
Duryee, A. Wilbur, 123

Eddy, C. E., 670
Ehrlich, David E., 363
Eichorn, Karl B., 111
Einstein, Robert A. J., 299
Eliot, Martha M., 236
Ellis, F., 249
Ellis, John D., 514
Epstein, Bernard S., 413, 675
Erf, Lowell A., 522
Erskine, Arthur W., 673
Evans, Titus C., 55
Everett, Marjorie, 125

Fariñas, P. L., 371, 448
Faust, Daniel B., 372
Feldman, Maurice, 370
Figi, Frederick A., 788
Finland, Maxwell, 1
Fischer, Frederick J., 292
Flaxman, Abraham J., 617
Follis, Richard H., Jr., 235, 236
Fong, E. E., 452
Fonts Abreu, Ernesto, 241
Foster, Miles E., Jr., 787
Ffangella, Alfonso, 242
Freedman, Paul, 112
Freid, Jacob R., 153
Freireich, Kal, 247
French, J. Douglas, 512
Fried, B. M., 520
Friedlander, J., 115
Friedman, Murray M., 292
Fulton, John F., 221, 662
Furlow, Leonard T., 511
Furst, Joseph B., 511

Garber, Robert L., 512
Garland, L. H., 37, 275, 489
Gellis, Sydney S., 111
Gill, A. Bruce, 515
Gobbel, W. G., Jr., 473, 478
Goin, Lowell S., 240
Golden, Ross, 495
Gore, Ira, 238
Graff, W. S., 44
Green, John R., 785
Greenberg, David M., 235
Greengard, Joseph, 121
Greiner, D. James, 119
Grimes, Elmer L., 107
Gunther, Lewis, 235
Guzman, Leonardo, 242

Haden, Russell L., 387, 394
Hadley, Lee A., 193
Hamilton, Joseph G., 111
Hankins, Walter D., 361
Hara, James H., 788
Harnett, W. L., 244
Hartley, J. Blair, 105
Hauch, Paul P., 237
Hawkins, James W., 790
Hawley, Sydney J., 672
Haymaker, Webb, 787
Hefke, H. W., 118, 370
Heilbrun, Norman, 189
Hemphill, James E., 236
Hench, Philip S., 519
Henshaw, Paul S., 789, 790, 792, 793
Herpel, Frederick K., 361
Herrmann, Julian B., 165
Heydemann, Julius, 362
Hille, Hermann, 643
Hiller, Glenn I., 119
Hinkel, C. L., 689
Hoff, Ebbe Curtis, 221
Hoff, Phebe M., 221, 662
Holmes, George W., 533

Holt, John F., 125, 420
Holvey, Ervin H., 360
Homans, John, 662
Horn, Robert C., Jr., 555
Howard, Campbell, 710
Howard, John C., Jr., 364
Howes, William E., 373, 673
Humphreys, Eleanor M., 369
Hunt, Claude J., 371
Hurst, Allan, 111

Idstrom, Linneus G., 224
Imber, Irving, 113
Ingber, Edmundo, 350
Ingraham, Franc D., 787
Ingraham, Louise P., 673

Jackson, Deborah, 236
Jackson, Deborah A., 235
Jamison, H. W., 396
Johnson, Richard M., 119
Johnston, Wayne A., 362
Johnstone, A. S., 108
Jones, D. E. A., 376
Jones, Harold W., 522

Kalayjian, Bernard S., 360
Kaplan, Abraham, 787
Kaplan, Ira I., 239, 246, 775
Kaufmann, Joseph, 464
Kaufmann, William, 120
Keys, Thomas E., 505
Khoo, F. Y., 333
Kirsh, David, 121
Klein, Andrew J., 189
Kleinberg, Samuel, 519
Klinefelter, Edmund W., 722
Kohn, Alfredo, 517
Kositchek, Robert J., 519
Kraft, Ernest, 365
Kresky, Philip J., 364
Kuhn, Harold H., 236

Lagomarsino, Enrique H., 515
Langford, Herbert, 224
Larkin, John C., 525
Lavner, Gerald, 361
Lawrence, Edwin A., 733
Lawrence, J. H., 44
Lederman, M., 108, 240
Leinwand, Irving, 123
LeMone, David V., 119
Lerner, Henry H., 717
Leucutia, T., 93, 487, 768
Levene, George, 363
Levenson, Stanley M., 1
Levine, Ida, 111
Levine, Samuel, 112
Lewis, Elbert K., 364
Lewis, Ira, 198
Lewy, Frederick H., 511
List, Carl F., 125
Livingstone, J. L., 244
Lloyd, Milton S., 231
Loehr, William M., 634
Lowry, Thomas, 365
Lowry, Thomas McG., 654
Lusk, Frank B., 364
Lyle, Donald J., 220

McCaw, W. W., 248
McCormick, Norman A., 674
McFadden, Irma, 121
McIlwain, Albert J., 369
MacKee, George M., 790, 791, 794
McLaren, John W., 107
McNattin, Robert F., 244
Macht, Stanley H., 372
Macy, Icie G., 504
Maguire, Daniel L., Jr., 360
Major, Ralph H., 661
Mansur, Edward E., 672
March, Herman C., 790
Marottoli, Oscar R., 237
Martin, Charles L., 394
Maxfield, J. R., Jr., 369
Mayneord, W. V., 240, 375
Mazer, Morton L., 27
Melamed, Abraham, 20
Melbin, M., 246
Menezes de Oliveria, Roberto, 220
Miller, Edwin M., 121
Miller, F. A., 522
Miller, H., 249
Miller, Henry, 366
Mitchell, Earl B., 116
Moersch, Herman J., 106
Molony, Clement J., 113
Mondolfo, Silvano, 518
Moore, John R., 516
Moore, Matthew T., 786
Morgan Russell H., 67, 198, 249, 627, 791
Morris, C. H., 621
Morrison, Howard J., 119
Mudgett, Charles S., 372
Munk, Julius, 118
Munson, Frederick T., 670
Munson, Henry T., 670
Muscolo, Domingo, 234
Mutscheller, Arthur, 790, 791, 794

Neville, R. L., 119
Nichols, R. L., 689
Noll, J. Emerson, 779

Olcott, Charles T., 114
Oldberg, Eric, 785
Olin, Harry A., 521
Oppenheimer, Albert, 454, 515
Oppenheimer, Ella H., 112
Osgood, Ellis C., 373, 511
Ottolenghi, Carlos E., 513

Page, Irvine H., 122
Palmer, Walter L., 369
Park, E. A., 236
Pascucci, Lucien M., 524
Pasternack, Joseph G., 120
Paterson, Edith, 250
Paterson Toledo, R., 234
Paul, L. W., 117
Pavlovsky, Alfredo, 234
Payne, Reginald T., 108
Pedersen, N. S., 117
Peirce, Carleton B., 464
Pendergrass, Eugene P., 555
Penha Godoy d'Alambert, J., 360
Pereira da Silva, C., 360
Perkins, Henrietta T., 662
Perloff, William H., 786
Perruelo, Nicolás, 517
Peters, Michael, 111, 238
Peterson, Vernon L., 362
Piatt, Arnold D., 173
Pinner, Max, 116
Piqué, José A., 523
Plati, John T., 511
Pohle, E. A., 117
Pomeroy, Lawrence A., 491
Pool, H. H., 247
Porter, D. C., 121
Portmann, U. V., 393
Puente Duany, N., 241
Pujadas, Amador A., 243

Quimby, Edith H., 55

Rabbi, Rodolfo A., 518
Ramsey, George H., 512
Raycraft, William B., 121
Reeves, Robert J., 674
Reiley, W. E., 370
Reilly, William A., 111
Resnick, B., 717, 730
Reynolds, Lawrence, 135
Richards, Charles M., 652
Rigler, Leo G., 365
Riley, Conrad M., 123
Ritvo, Max, 1
Robbins, Laurence L., 367
Roberts, F., 124
Roberts, Ffrangcon, 244
Robin, Percival A., 782
Rogers, G. L., 249
Rose, Edward, 786
Rosenberg, Edward F., 519
Rosenthal, Louis M., 360
Rowland, Driver, 366

Rowland, Willard D., 788

Salmon, D. D., 512
Sante, L. R., 521
Santanowsky, Sara, 517
Schajowicz, Fritz, 238, 518
Schearer, W. S., 237
Schindler, Rudolf, 369
Schmidt, Ernst A., 362
Schulz, Milford D., 533
Schwachman, Harry, 123
Schwartz, Henry, 523
Schwartz, Leo, 109
Schwarz, Gottwald, 337
Scott, K. G., 44
Scott, Wendell G., 511
Selman, Joseph, 555
Shapiro, Robert, 115, 667
Shinall, Harold L., 110
Shrader, E. Lee, 521
Shrader, J. C., 122
Silverstone, Sidney M., 203
Smith, S. Willard, 511
Soley, Mayo H., 111
Solis-Cohen, Leon, 112
Speigler, H., 106
Spencer, R. R., 249
Spies, Tom D., 239
Spillman, Ramsay, 96
Staples, O. Sherwin, 513
Stein, George H., 364
Steinhausen, Theodore B., 511
Stenstrom, K. Wilhelm, 246, 374
Sterman, Ida A., 363
Stone, Robert S., 392
Strain, William H., 511, 512
Stuart, E. A., 785
Sunderman, F. William, 786
Swenson, Paul C., 325

Taussig, Helen B., 112
Templeton, Frederic E., 369
Terrizzano, Arturo J. M., 243
Terrizzano, Manuel F., 243
Thomas, Colin G., Jr., 299
Thomas, S. F., 275
Thompson, Charles M., 16, 107
Thornton, T. F., Jr., 116
Tinney, William L., 106
Tod, Margaret C., 108
Trask, Burton W., 331
Turnbull, Frank, 787
Tyau, Steven, 110

Uhlmann, Erich M., 394
Ullmann, Henry J., 393, 673

Valls, Jorge E., 238
vanDemark, Robert E., 292
Viamonte, J. Manuel, 371
Vilter, Richard W., 239

Walker, A. Earl, 523
Waring, James J., 362
Warren, Stafford L., 511
Wasson, W. & Walter, 575
Watkins, Melvin B., 717
Weatherwax, J. L., 101
Weber, Harry M., 319
Weeks, Kenneth D., 372
Weens, H. Stephen, 588
Weinstein, Mandel, 110
Wheatley, Frank E., 348
Widmann, Bernard Pierre, 377
Wiles, F. J., 115
Wilner, Daniel, 594
Wilson, C. W., 374
Windeyer, B. W., 107
Wolcott, E. Clinton, Jr., 511
Wolf, Bernard S., 376
Wright, W. D., 106
Wycis, Henry T., 787

Young, John M., 122

Zanca, Peter, 361
Zavod, William A., 356
Zimmerman, Burton M., 20

VOLUME 55 JUNE, 1946 NUMBER 6

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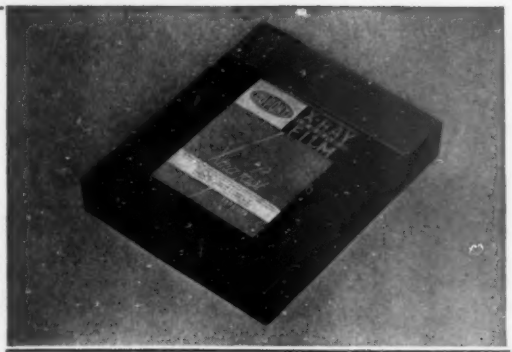

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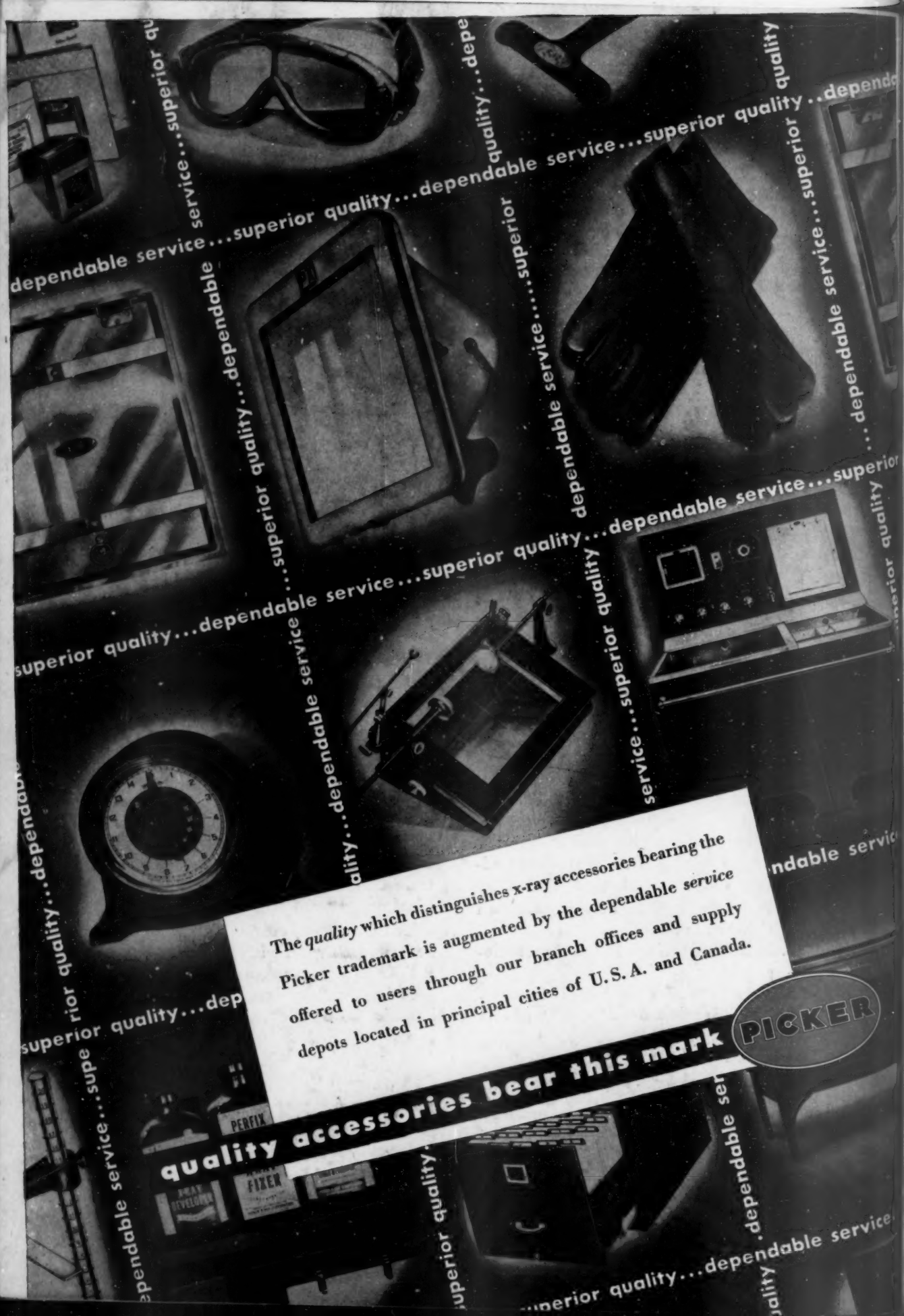
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